Education & Video Games:
Does awareness of educational intention affect a video game's educational effectiveness?

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ABSTRACT

Background: For years, studies have examined whether the medium of video games can be an effective tool for education. While the medium has long been considered a distraction rather than a motivation – especially in relation to education – recent years have shown an increasing interest in video games' ability to attract and captivate people of all ages. This thesis aims to examine if a negative attitude towards education negates any or all of the promising characteristics that make video games a potential tool for educating. In particular, this thesis focuses on examining if educational video games could potentially be more effective (in educating) if the intention to educate is concealed.

Methods: First, a survey was applied to examine how participants of different ages generally view educational video games (based on previous interaction with the medium). Then, an experiment was designed to examine whether transferability of educational content differed between two conditions – an open- and a closed-labeled one.

Results: Results of the survey reveal a bias towards education, with participants (*n* = 30) generally preferring regular video games to educational ones. Results of the experiment on correlation between educational awareness and educational effectiveness, using open-labeled (*n* = 10) and closed-labeled (*n* = 10) groups, do not support the hypothesis.

1. INTRODUCTION

On the 12th of January 1999, my parents decided to buy my sister and me a Nintendo 64 home video game console. While I had already played on video game consoles before (e.g. at a friend's house), I never had the pleasure to actually own one at home. The Nintendo 64 had many different kinds of video games, but one immediately had my full attention: action-adventure game *The Legend of Zelda: Ocarina of Time* (Nintendo, 1998). Mesmerized by the fantastical world in which the game takes place, I was thoroughly entertained and wished to finish the game, compelled by my curiosity of what else the video game had to offer me.

However, I soon reached an obstacle: while certainly not a difficult game, *Ocarina of Time* does require a certain understanding of the English language in order to progress. Considering that I was only nine years old at the time (an age where Dutch children have barely gotten English class yet, if at all), my inability to comprehend what the video game often tasked me to do in order to progress became increasingly difficult, to the point that, eventually, I was forced to accept my predicament: I was stuck.

At this point, my nine-year-old self had two options: (1) conclude that my comprehension of the English language was insufficient, quit playing and not find out what else would happen in the game or (2) attempt to improve my understanding of the English language in order to continue playing and find out how the video game would progress. Being extremely motivated by the game's entertainment value, I chose the latter. By reading different English magazines and trying to figure out what the articles discussed, I eventually managed to enlarge my knowledge on the English language and, in time, defeat *Ocarina of Time*'s final boss and save Princess Zelda.

For years, I believed this personal experience of mine showcased an effective method of motivating educational development amongst children by combining education with entertainment. After all, it was because of entertainment (i.e. *Ocarina of Time*) that I was extremely motivated to educate myself (i.e. learn the English language).

Naturally, this concept of "making education fun" is nothing new: since its introduction in the 1980s (Mitchell, 1983), the medium of educational video games has focused on making learning an appealing process for children, teenagers and even adults. Research on educational video games has primarily revolved around the medium's potential to educate in different, more effective ways (compared to other media) and in what ways (or, rather, in what circumstances) this potential can come to fruition. As such, the effect of educational video games on different types of participants (e.g. children, teenagers, adults) and in different areas of education (e.g. motivation of self-education, making education a more enjoyable experience, asserting participants' capabilities in handling educational material) are still being studied prominently.

Despite a general interest in the potential of educational video games, certain aspects do not yet seem to have been (sufficiently) explored by researchers. One of these would be the participants' attitude towards and preconceptions of education. While the purpose of video games is commonly considered to solely revolve around entertainment, many believe education and the act of learning to be quite the opposite and, in some cases, boring (Pintrich and Schunk, 2002, Mann and Robinson, 2009). Arguably, this is one of if not the main reason behind the general interest in educational video games: they are able to make education, which many consider "boring", become (more) appealing by placing it in entertainment, which many consider "fun".

This contradiction between education and entertainment, however, leads me to assume that educational video games risk reducing their potential when their intention to educate is apparent to the participant. Moreover, it makes me wonder: would a video game be more effective in educating if the participant is not aware of the intention to educate (thus preventing the participant from having a negative attitude towards the game)? If so, this would indicate that the general attitude towards education, which I believe to be negative, prevents the potential of video games, intended to make education fun, to come to fruition.

In order to discover if this is indeed the case, I focused this research on the following question: are video games more effective in educating if the intention to educate is concealed from the participant? To compose a suitable answer to this question, I carried out two separate tests. First, a survey was conducted to determine a possible presence of a precedent attitude towards educational video games. Second, an experiment around a video game was performed with an open- and closed-labeled group to determine a connection between awareness of educational intention and the educational effectiveness of the game.

2. RELATED WORKS

Before documenting the survey and experiment of this thesis, characteristics of educational video games need to be discussed. As such, an overview will be given on past and current research on educational video games, showing both the medium's promising features and possible disadvantages when applying it to the field of education.

2.1 DEFINITIONS

Since this research aims to study a correlation between awareness of educational intention and effectiveness of educational video games, it is important to first discuss the medium's potential to educate. What are the benefits of applying educational video games to education? Arguably, this question has been the main focus of prior research into educational video games. With the intention to determine how the medium can help or even improve education, researchers have examined different aspects of educational video games. As such, the results of these studies on the medium allow an overview of both the characteristics and capabilities of educational video games.

What, then, defines an educational video game? According to Wikipedia, educational games 'are games explicitly designed with educational purposes, or which have incidental or secondary educational value'. However, the web-based encyclopedia contains a separate article for educational video games, defining these as 'educational software which is primarily about entertainment, but tends to educate as well and sells itself partly under the educational umbrella'. Furthermore, educational games are often placed under the banner of "educational entertainment" (often referred to by its portmanteau "edutainment"), described by Merriam-Webster as 'entertainment (such as through games, films, or shows) that is designed to teach something'. Thus, with these descriptions in mind, educational video games - a sub-category of educational games, which in turn are part of edutainment - can be defined as digital games that aim to entertain, but simultaneously educate intentionally or unintentionally.

This, however, gives rise to a new question: how do educational video games differ from regular video games? While it is often the case that educational video games are intentionally designed to both educate and entertain players, the purpose of educating is not, as mentioned in the previous paragraph, the medium's defining characteristic. A video game is (or can be) considered educational if, aside from entertaining the player, it educates in some shape or form, regardless of its intentions. Following this train of thought, regular video games would be missing this educational element, but still contain the element of entertainment. Arguably, regular video games often seem to be primarily focused on providing this. While puzzle-game *Candy Crush* (King, 2012), shooting-game *Call of Duty: Advanced Warfare* (Sledgehammer Games, 2014) and platform-game *Super Mario 3D World* (Nintendo, 2013) differ immensely in both style and substance, they all share a singular purpose: to entertain. As such, the difference between a regular video game and an educational game is not defined by the intention (to either entertain or to simultaneously entertain and educate), but by the game's content and whether this educates the player, not just in terms of subject matter or topic, but in the way the game is played.

Of course, what makes specific content educational can be regarded as subjective. If education is simply defined by the act of learning, something as simple as jumping over obstacles in a video game could be considered educational as it teaches players how to dodge objects. In practice, however, something more is expected of a video game for it to be viewed as educational. An example that illustrates what this "something more" refers to is creative sandbox video game *Minecraft* (Mojang, 2011). While development of *Minecraft* focused on designing a video game with which many different types of players could have fun, the game turned out to be an extremely useful tool for educational purposes since its release. Described in *Scientific American* as 'immersive and creative, [and] an excellent platform for making almost any subject area more engaging' (Gershenfeld, 2014), *Minecraft* has been used by many teachers to educate their students on different kinds of educational topics. Consequently, the use of *Minecraft* for educational purposes has led current owner Microsoft to announce *Minecraft: Educational Edition*, a version of the game more suitable for use in educational environments, slated to be released in 2016. In a similar fashion, video game developer Valve decided to release *Portal 2 – Educational Version* (2012), an alternate, educational version of their video game *Portal 2* (2011), after noticing that the original *Portal 2* was actively being used to teach students problem-solving and educating them on physics. In both cases, then, what caused these video games to be considered educational video games is the fact that their content proved to be an effective tool with which players can develop and improve abilities that are relevant to and useful for education and, as a whole, society.

2.2 ADVANTAGES

As for whether educational video games are actually effective in educating and, if so, to what extent, researchers seem to (somewhat) agree on an answer to the first question, but disagree on an answer to the second. Most if not all studies on the educational potential of video games acknowledge the medium's ability to provide a new and different method of learning for students. In particular, video games' ability 'to provide motivating and meaningful learning experiences' (Sun and Gao, 2016) seems to be prominently emphasized when discussing the possible uses of educational video games.

While some studies show a careful optimism towards the medium, stating for example that educational games 'appear to have a positive effect on elementary school students' motivation leading to enhanced learning outcomes' (Sun and Gao, 2016), other studies appear more convinced on its effectiveness, claiming 'there has been considerable success when games are designed to address a specific problem or to teach a certain skill' (Griffiths, 2002). In a 2015 article in *American Psychological Association*, however, University of California psychologist Richard Mayer states that 'despite the growing popularity of [interactive learning] games, research has yet to determine whether they really help children learn'. Claiming that 'research on games is highly diverse, disorganized and unfocused, with a significant number of methodologically flawed studies', Mayer argues that 'a lot of very careful experimental research that looks at learning outcomes' is necessary in order to properly establish video games' effectiveness in educating (Mayer according to Novotney, 2015). Agreeing with this statement, Douglas Clark adds

'that more research is needed on exactly which aspects and design elements of digital games work best at improving student learning' (Clark according to Novotney, 2015). Similarly stressing the need for additional research, Susan Barnett refers to the diversity and variety of video games as a medium when claiming that the 'transfer from different kinds of games needs to be assessed on a case-by-case basis'. Seeing how video games can be extremely different from each other in both presentation and content, Barnett argues that 'for all these various forms of learning games, understanding how these learning experiences transfer across the dimensions of content and context […] should allow us to better evaluate the utility of educational investment in video game learning' (Barnett, 2014). Nevertheless, Eva Baker admits that, despite this current uncertainty and lack of strong evidence supporting 'games' academic effectiveness, the allure of using games for learning is hard to pass up' (Baker according to Novotney, 2015).

This, then, leaves the question of what characteristics of an educational video game are so "alluring" to the field of education. As previously mentioned, studies seem to agree that, since video games have the capacity to be 'highly engaging and motivating', educators could use these qualities 'to facilitate learning' (Plass *et al*, 2013). More so than other media, video games allow for players to hold more control over what is experienced, providing 'elements of interactivity that may stimulate learning' (Griffiths, 2002). Simultaneously, video games are often perceived as 'fun and stimulating for participant, [making it] easier to achieve and maintain a person's undivided attention for long periods of time' (Griffiths, 2002). In her discussion of the appeal of applying video games to the field of education, Fran Blumberg similarly mentions "interactivity" and "control" as two promising features of the medium, but adds an additional number of characteristics that show potential. Blumberg mentions "identity", 'which refers to players' opportunity to form relationships and linkages with game characters or to become game characters via avatar construction', as a characteristic that could help keep the players' interest while educating them. Furthermore, a video game is able to provide "feedback", 'information players receive about the efficacy of their game actions, which in turn scaffolds the course of their gameplay'. Another promising characteristic of the medium is "immersion", i.e. 'players' sense of presence or integration within the game', further stimulating the players' interest (Blumberg, 2014).

The medium's most persuasive feature, however, would arguably be video games' popularity and the fact that, in general, it is considered an entertaining and enjoyable pastime, especially amongst young and adolescent audiences. Its popularity is reflected in a 2016 report by the Entertainment Software Association (ESA) on average use of video games, which states that '63% of U.S. households are home to at least one person who plays video games regularly (3 hours or more per week)' (ESA, 2016). Interestingly, while video games are often considered to be aimed towards male audiences, with some studies claiming that 'boys [have] a stronger affinity for video game play than girls' (Braun *et al* according to Kappers, 2009), ESA statistics of 2016 reveal that 41% of people who play games in the U.S. are in fact female. Further demonstrating the medium's popularity is the ESA's estimate of $23.5 billion spent on video games in 2015 alone. Together, the above elements illustrate quite well why many are interested in applying video games to education: not only is the medium generally loved by many, but with an industry around it that is still growing in popularity, the possibility that this love for video games could be applied to education in order to make learning more appealing is indeed a promising one.

2.3 DISADVANTAGES

However, the medium is not without its disadvantages and risks when applying it to the field of education. For one, the aforementioned lack of research on (1) its academic effectiveness and (2) how the difference between video games translates to the transferability of learning not only causes a certain cautiousness towards applying the medium to educational environments, but simultaneously makes it difficult to determine to what areas of education video games could and should be applied. While studies continue to examine what fields of education could benefit from the use of video games, the current state of uncertainty appears to prevent educators from deciding if the use of video games in education is superior to more conventional methods of educating.

Another element that stands in the way of its application to education is the association between video games and negative effects. Some consider the medium dangerous, believing that 'playing violent video games may increase the risk of aggression in players' (Ferguson, 2007). Others fear the possibility that those who play video games become addicted to it, an addiction that, despite showing 'relatively little physical risk', still inflicts serious damage on the addicted as it 'will almost certainly create a number of significant social problems' (O'Connor, 2014). While many to this day debate just what risks the medium may or may not pose, the discussion causes certain groups to remain skeptical towards the use of video games for educational purposes, fearing it may do more harm than good.

Arguably closest to the topic of this thesis, applying video games to education could diminish the medium's promising characteristics in the process. In October 2015, Marc Brackett, Director of the Yale Center for Emotional Intelligence, revealed the results of the "Emotion Revolution" survey, a survey intended to examine how American high-school students felt about their schools. With a diverse sample size of 22.000 students, Brackett revealed that 75% of participants gave a negative response when asked how they felt about school. On average, students indicated that they feel bored 70% and stressed 80% of the time while at school. Furthermore, the most common words used when students were asked to describe their current emotions associated with school were "tired" (39%), "stressed" (29%), and "bored" (26%). Together, these results reveal a generally negative attitude towards education amongst the survey's participants. Consequently, in the event that this negative view on education is persistent, using a video game to educate could reduce the effectiveness of a majority of the medium's potential characteristics (as discussed in 2.2). Simply being aware of the educational element could already cause certain players to develop a bias towards an educational video game because of the game's connection with education. Additionally, the association between education and (1) exhaustion, (2) stress and (3) boredom, as discussed in the aforementioned survey, could make players 'perceive educational games as too cognitively demanding or as insufficiently challenging' (Blumberg, 2014). Thus, the possibility that a negative attitude towards education could

undermine or nullify some or all of video games' promising characteristics seems to be a plausible one.

3. METHODS

For this thesis, research was performed in two different forms. Firstly, a survey was conducted in order to determine if a negative attitude towards educational video games is apparent. Secondly, an open- and closed-labeled experiment was conducted to study if concealing the educational intention of a video game affects its educational effectiveness.

3.1 SURVEY

For the first test, a survey in Dutch was used to study participants' views on educational video games in general. In particular, the intention of this survey was to establish if participants showed a negative attitude towards educational video games prior to actually playing the games. The survey, available both in printed form and digitally, consisted of two segments. For the printed version of the survey, please see **Appendix Figure 1**.

The first segment aimed to examine participants' attitude towards educational video games and video games intended for entertainment prior to playing. Participants were presented with two different covers of video games: one distinctively presented itself as educational (option A), the other as entertainment (option B) (an example pair is shown in **Figure 1**).

Figure 1: Two covers used in the survey, with A (left) advertising the game to be of educational nature, while B (right) presents itself as entertainment.

Participants were asked four questions regarding these two covers. First, they were asked to describe (in one or two sentences) what kind of video game they would expect option A to be, based on the information available on the cover of the game. Second, the same was asked regarding option B. Third, participants were asked to indicate which of the two options they would prefer to play on a 6-point Likert scale. Fourth, participants were requested to elaborate on their decision, i.e. why they would prefer one of the options to the other. This process, of the above four questions in relation to two covers, was done five times. While each round featured two new video game covers (one suggesting to be educational, the other to be entertainment), the featured questions remained identical.

The second segment of the survey inquired about personal information: participants were asked to provide their gender, age and highest education level completed. Furthermore, familiarity with video games was measured by

letting participants indicate how often they play video games (on a one-to-five scale, with one being "never" and five being "a lot") and on what platforms (e.g. video game consoles, tablets, mobile devices) they play these games (multiple answers were allowed here). Finally, participants were asked how familiar they were with the fictional character featured on all video game covers of the survey and / or if they had played any of the video games these covers belonged to.

Present on each cover (in total, the survey contained 10 different covers) was *Rayman*, a fictional character designed by Ubi Soft (currently Ubisoft) that has been featured in several video games, the first of which was released in 1995. Every cover used in the survey contained elements that suggested the nature of the video game it represented to be either educational or entertainment. Of the two options, the one suggesting education would announce its content to revolve around education (e.g. by use of text such as 'learn Swedish with *Rayman*!'), whereas the one suggesting entertainment would advertise its content to be based around having fun (e.g. by use of text such as 'contains lots of enjoyable levels!'). For each of the five educational covers, the educational content advertised was a specific language, i.e. German, Japanese, Spanish, Russian or Swedish.

In order to be as certain as possible that participants would base their choice of preference on either the cover representing education or the cover representing entertainment, other factors were either removed or altered so as not to risk these potentially influencing participants' decisions. Each cover featured in the survey showed the same artwork (i.e. same characteristics, pose, coloring etc.) of the *Rayman* character so as to prevent participants basing their choice on preferred character design. Layout of the covers (positioning of text, images and characters) was kept as similar as possible. Since a difference in language between two covers could affect a participant's choice (e.g. if he or she does not comprehend one of two languages), text on covers was translated into Dutch and authentically changed (with the use of Adobe *Photoshop*). Furthermore, text that indicated the video game's intended audience (e.g. children below ten) was removed. Lastly, every pair of covers in the survey contained a generally similar color scheme in order to lower chances of participants' preference of color playing a role in their choice. Together, these alterations caused the distinction between every grouping of covers to be primarily focused on their intention (to either educate or entertain).

3.2 EXPERIMENT

Whereas the first test was intended to establish if and to what degree a negative attitude towards educational video games is present amongst participants prior to playing, the second test focused on examining if and how awareness of the intention to educate affects the effectiveness of a video game in educating. In order to properly determine whether awareness of an educational intention has any influence on the effectiveness of the educational element of a video game, participants of this experiment were divided into two groups representing two opposing conditions: an open-labeled condition (Group 1) and a closed-labeled condition (Group 2).

3.2.1 OPEN- V.S. CLOSED-LABELED STIMULI

During the experiment, both groups were asked to play the same level of the same video game; however, to the open-labeled group, the game was presented as an educational video game, whereas the closed-labeled was told the game is simply meant for entertainment. As such, a test was used on participants of both groups before and after playing the game to verify how effective the educational content had been (i.e. how much participants' educational knowledge had improved by playing). The results of both groups of participants were then compared to each other to establish if one group showed a higher improvement than the other.

To members of Group 1, the video game used in the experiment was introduced as an educational video game prior to playing in three ways. Firstly, Group 1 was given the impression that the video game's intention was to educate by presenting a cover of the video game that prominently features information referring to its (supposed) educational nature. Secondly, participants were told a description of the video game's premise, i.e. what kind of gameplay the game consisted of and how this related to its educational nature. Thirdly, Group 1 was shown an edited version of the video game's trailer (note that participants were unaware of the altering of the content), consisting of information referring to the (supposed) educational nature of the game similarly to the previously mentioned cover.

To Group 2, the video game was presented as a "normal" one (i.e. meant for entertainment) in three similar ways. Firstly, Group 2 was shown a cover of the video game that gives the impression that the game's content is meant to entertain the player; in no way did the information present on the cover suggest the video game to possess an educational intention or to contain any educational material. Secondly, participants were given a very similar description of the video game's premise as the one told to Group 1 (i.e. a description of the game's gameplay), although any reference to the educational nature was left out. Thirdly, the original, unaltered trailer of the video game was shown, featuring no elements that reveal or suggest an educational intention. The main difference, then, between how the video game was presented to Group 2 compared to Group 1, was the supposed educational intention of the video game; apart from that, instructions were similar.

3.2.2 EXPERIMENTAL TASK

To perform the experiment of this thesis, a specific kind of video game was required. More precisely, whatever video game would be used for this experiment would have to meet certain specific requirements. Firstly, it should be possible to convincingly and believably present the video game as both an educational video game and as a regular video game intended solely for entertainment. Secondly, the video game should feature some form of content that is considered educational or heavily related to education. Thirdly, playing the video game should help players improve their educational knowledge or abilities, either by providing new information or by training the player. Fourth, the educational aspect of the video game should have an effect on the player after only a short period of playing (i.e. it should not be required to play the game for a number of hours before any effect related to the educational aspect would be noticeable). Fifth, the video game's gameplay mechanic(s) should be accessible to any kind of person,

regardless of familiarity with video games in general. Sixth, the video game should be accessible to players of all ages and genders.

With these six requirements in mind, popular video game *World of Goo* was chosen to be used in this experiment. Designed and published by developer *2D Boy*, *World of Goo* was released in 2008 on Nintendo's Wii and Microsoft's Windows (though it was later ported to additional platforms, such as Apple's OS X and iOS, due to its popularity). Being a distinctive puzzle video game, *World of Goo* revolves around the concept of creating structures of different sizes with balls of "goo" in order to progress. In each level, players are tasked to make sure a number of "goo balls" reach the exit (represented by a pipe). To achieve this, the game requires players to use different types of goo balls (which vary in function) to create structures that allow the goo balls to reach the level's exit. Players must overcome environmental obstacles while simultaneously remaining aware of forces such as buoyancy and gravity in order to keep their structures stable enough for goo balls to reach their destination. The further one progresses into the game, the more challenging *World of Goo* becomes, demanding more complex structures and combinations of (types of) goo balls in order to complete a level. As such, players are expected to think more creatively and become more efficient in building their structures if they hope to succeed.

This element of simultaneously helping the player improve (by playing) and requiring the player to improve (in order to progress) allows *World of Goo* to be considered an educational video game (regardless of the developer's intentions). Only 'by engaging in exploratory behaviors, observations, reflections, and continuous hypothesis making and testing' (Shute & Kim, 2012) are players able to complete the video game's levels. While not intended as an educational video game, *World of Goo* nonetheless encourages and stimulates players to improve their capacity to observe, analyze and react simply by playing and trying to progress.

More importantly (in regard to the topic of this thesis), *World of Goo*'s gameplay requires players to understand and work with forces commonly associated with what is known as "mechanical aptitude". Mechanical aptitude refers to an individual's capacity to 'recognize which mechanical principle is suggested by a test item' (Muchinsky, 2006). Since 'tests of mechanical ability are highly predictive of performance in manufacturing / production jobs' (Muchinsky, 2004), "mechanical aptitude tests" are often used by companies and organizations (related to manufacturing and production) to examine which individuals are best for a job. Concepts related to (and tested by) mechanical aptitude tests include sound and heat conductance, velocity, gravity and force (Muchinsky, 2006). Although some of these topics, such as heat conductance, are not present in *World of Goo*'s gameplay (more on this in a moment), other concepts, such as velocity, gravity and force, are heavily featured in the game. In fact, to complete *World of Goo*'s diverse levels, players have to apply their comprehension of these concepts to the obstacles presented to them while simultaneously (through trial-and-error) improving this comprehension by interacting with the game. Considering that (1) *World of Goo*'s gameplay features a multitude of concepts related to mechanical aptitude and (2) an individual's mechanical aptitude can be measured with the use of mechanical aptitude tests, the decision was made

to let mechanical aptitude represent the educational aspect of this experiment. Thus, the experiment was designed in such a way that participants' level of mechanical aptitude would be measured (both before and after playing *World of Goo*) in order to determine a difference between the two groups.

3.2.3   EXPERIMENTAL PROCEDURE

In order to properly determine a possible difference between the open-labeled and closed-labeled groups, a number of different measurements were required during the experiment. Firstly, participants' level of mechanical aptitude before and after playing *World of Goo* should be measured. Comparing results of the second test to the first would allow determining whether *World of Goo* helped participants improve their level of mechanical aptitude. More importantly, the improvement of both groups after playing *World of Goo* could then be compared to each other to establish if one group showed a significant difference in improvement over the other. As such, the educational effectiveness of both conditions could be examined, allowing a verification of the hypothesis of this thesis. Secondly, specific personal details would be required for assessing whether one group's participants could have a possible advantage over the other. In particular, the participant's (1) age, (2) gender and (3) educational level should provide the information necessary for establishing a possible difference in background between both groups. Thirdly, participants' opinion of *World of Goo* (after playing) should be measured to examine if awareness of educational intention has an influence on their enjoyment of the game. Fourth, participants' familiarity with both the *World of Goo* video game and the medium of video games in general should be measured in order to further establish a possible advantage of one group over the other. Fifth, asking the participants of both conditions if they believed *World of Goo* had educated them on something and, if so, what they had learned from playing it could provide further insight into a possible difference of attitude towards the game between both groups.

While *World of Goo*'s gameplay requires the player to apply and improve his or her understanding of a majority of concepts and forces that correspond with topics featured in the average mechanical aptitude tests (henceforth abbreviated as MATs), there are an additional number of technical abilities belonging to the category of mechanical aptitude that are not present in or involved with the video game. For example, *World of Goo* does not feature any obstacles that require knowledge on heat conduction (i.e. the transfer of heat). As such, using a regular MAT before and after *World of Goo* to measure a possible improvement in mechanical aptitude could possibly provide unreliable results since the questions of the test would not always focus on *World of Goo*'s gameplay mechanics. Thus, for this experiment, two MATs were created (MAT[1] and MAT[2]) that exclusively contained questions involving mechanical abilities that are featured in *World of Goo* (to see MAT[1] and MAT[2] in their entirety, please see **Appendix Figure 2**).

Both the first and second MATs featured 16 multiple-choice-questions in total. Of these 16 questions, every four questions belonged to one of four different categories, with each category revolving around forces related to mechanical aptitude and featured (to varying degrees) in *World of Goo*'s gameplay mechanics: (1) gravity and weight, (2) velocity and direction of circular objects, (3) balance and (4) movement. Every question was accompanied by an image that illustrated the content of the question. While the 16 questions varied in difficulty, no prior education or background in mechanical or technical areas was required to answer them; each question was answerable with common knowledge related to the aforementioned concepts. In order to answer the questions, participants were required to apply their experience with and knowledge on these concepts to different situations and problems. For example, participants were asked to use their understanding of gravity and weight to determine how certain objects fall or use their understanding of balance to decide the best way for someone to remain in a balanced position. Participants were given a time limit of 10 minutes for each test. All questions, including their accompanying images, were taken from one of several existing, professionally-designed MATs available digitally or in written form; however, the original text of these tests was translated to Dutch and, in case of some questions, content and illustration was altered to better suit the overall theme of this experiment. To ensure measurements would provide an accurate indication of improvement after playing *World of Goo*, questions of MAT[1] corresponded to questions of MAT[2] (and vice versa) regarding the concepts and forces that were being quizzed (e.g. question 1 of MAT[1] corresponded to question 2 of MAT[2] as both revolved around division of weight).

After completion of the first MAT (or if the ten-minute-time limit had passed), participants were introduced to *World of Goo* in three steps. First, participants were each given a video game case featuring either an educational cover or an entertainment one (as mentioned before, this depended on the group). To clarify, the educational cover advertised *World of Goo* as a game that focuses on educating the player, while the entertainment cover advertised the game to revolve around entertainment. Both the educational cover and the entertainment one are shown in **Appendix Figure 3**. Then, in a similar fashion, one of two trailers of *World of Goo* was shown, one trailer advertising the game as educational, the other as entertainment. Lastly, *World of Goo*'s controls, goal and basic mechanics were explained verbally to the participants. Next, participants were given ten minutes to complete a single level of the game, titled *Fisty's Bog* (**Figure 2**).

Figure 2: The level of *World of Goo*, titled *Fisty's Bog*, that participants were asked to play.

In *Fisty's Bog*, players are required to build a construction from the left of the map to the right in order to ensure the "Gooballs" arrive safely at the exit. Both the bottom and top of the level, however, are covered with deadly spikes. Furthermore, the bigger a player's construction becomes, the more intense it is influenced by forces such as gravity or buoyancy, in turn complicating the building of the structure.

By using balloons (which enable lifting of the construction), players are required to prevent their construction from falling down. To complete *Fisty's Bog*, players need to think ahead and plan when building their structure, while simultaneously assessing how forces like gravity, buoyancy and weight can help them with or hinder them in achieving their goal.

At the end of the experiment (after completing MAT[2]), participants were asked to fill in a short (printed) survey of eight questions. The first three questions asked participants about their age, gender and educational level. Next, three questions focused on participants' (1) familiarity with *World of Goo* (i.e. if they knew, had heard of or seen the video game before and if they had previously played the video game), (2) enjoyment of *World of Goo* (indicated by giving the game a grade between 1 and 10) and (3) willingness to play *World of Goo* again. For the last two questions, participants were asked whether they felt like playing *World of Goo* had taught them something and, if so, to describe what they had learned from playing it.

To summarize, the experiment consisted of the following five segments:

1. The first (a priori) MAT (with a time limit of ten minutes), intended to measure the participants' quality of mechanical comprehension before playing *World of Goo*;
2. The introduction of *World of Goo* to participants, which in turn consisted of the presentation of (1) a (condition-dependable) cover, (2) a (condition-dependable) trailer and (3) an explanation of the video game;
3. The playing of *World of Goo*, during which participants were tasked to complete a single level (i.e. *Fisty's Bog*) within ten minutes;
4. The second (a posteriori) MAT (with a time limit of ten minutes), intended to measure a possible improvement of the participants' quality of mechanical comprehension after playing *World of Goo*;
5. The short survey, wherein participants were inquired about personal information, familiarity with games and their view on *World of Goo*;

4. RESULTS & ANALYSIS

4.1 SURVEY

In total, 30 participants completed the survey either in digital or printed form. In total, 18 participants were male while 11 participants were female; 1 participant did not indicate gender. One participant was between the ages of 11 and 15, three participants between 16 and 20, nine between 21 and 25, ten between 26 and 30, two between 31 and 35, one between 46 and 50 and four participants over 50 years old. Regarding how regularly in a week they play video games, participants displayed an average of 2.90 (σ = 1.14) on a 5-point scale (with 1 representing "never" and 5 representing "a lot").

As mentioned, participants were asked to indicate which one of two video games they would prefer to play, based on what the covers of these games suggested. Participants were asked to do this five times, with each time presenting one cover suggesting an educational game and one cover suggesting a regular one. Results for each individual educational content (i.e. one of five languages) are shown in **Table 1**, with the four columns displaying (from left to right) (1) content of the educational cover

(i.e. the language), (2) mean preference on a 6-point scale of this preference (standard deviation (σ) in brackets) and (3) *p*-values of the one-sample t-tests used to acquire these results. Note that, regarding the 6-point scale, 1 represents absolute preference for the educational game cover, while 6 represents absolute preference for the entertainment game cover (neutral preference thus lies at 3.5).

Language	Preference	*p*
German	5.00 (1.39)	2.03E-06
Japanese	4.37 (1.83)	0.0147
Spanish	4.27 (1.68)	0.0184
Russian	4.37 (1.77)	0.012
Swedish	4.83 (1.39)	1.27E-05
Combined	*4.57 (1.00)*	*2.49E-06*

Table 1: Mean preference (standard deviation (σ) in brackets) amongst participants (*n* = 30) for educational- or entertainment cover on a 6-point scale, as provided by one-sample t-tests (hypothesized mean = 3.5).

Additionally, **Table 2** shows a comparison of these five languages in relation to participants' mean preference for the educational- or entertainment cover. Note that a positive difference (Δ) in mean (μ) indicates that participants preferred the language on the top over the one on the left, while a negative difference in mean indicates a preference for the language on the left over the one on the top. For example, the difference in mean between Japanese and Swedish is -0.47; thus, participants' preference for the educational cover advertising Japanese had a higher mean (0.47 higher, to be precise) on the 6-point scale compared to the one advertising Swedish.

	Swedish	Russian	Spanish	Japanese
German	$\Delta\mu$ = 0.17 p = 0.64	$\Delta\mu$ = 0.63 p = 0.13	$\Delta\mu$ = 0.73 p = 0.07	$\Delta\mu$ = 0.63 p = 0.14
Japanese	$\Delta\mu$ = -0.47 p = 0.27	$\Delta\mu$ = 0 p = 1	$\Delta\mu$ = 0.1 p = 0.83	
Spanish	$\Delta\mu$ = -0.57 p = 0.16	$\Delta\mu$ = -0.1 p = 0.82		
Russian	$\Delta\mu$ = -0.47 p = 0.26			

Table 2: Comparison of the five languages presented as educational content in relation to mean preference for educational- or entertainment cover, showing difference in mean ($\Delta\mu$) and *p*-value of the two-sample unpaired t-tests (two-tailed, assuming unequal variances) used.

Surprisingly, there appeared to be some differences between female (n^f = 11) and male (n^m = 18) participants in preference for education or entertainment. These differences can be found in **Table 3**, with the six columns displaying (f. l. t. r.) (1) content of the educational cover (i.e. the language), (2) mean female preference on a 6-point scale, (3) mean male preference on a 6-point scale and (4) *p*-values of the two-sample unpaired t-tests used to acquire these results (standard deviation (σ) of female- and male preference is displayed in brackets behind the means).

Language	♀ Pr	♂ Pr	p
German	4.82 (1.47)	5.06 (1.39)	0.67
Japanese	3.55 (1.75)	4.78 (1.77)	0.08
Spanish	3.91 (1.45)	4.61 (1.75)	0.25
Russian	3.27 (1.74)	4.94 (1.51)	0.02
Swedish	4.27 (1.56)	5.17 (1.25)	0.12
Combined	*3.96 (0.8)*	*4.91 (0.98)*	*0.01*

Table 3: Mean preference (standard deviation (σ) in brackets) of female ($n^f = 11$) and male ($n^m = 18$) participants for educational- or entertainment cover on a 6-point scale, as provided by two-sample unpaired t-tests (two-tailed, assuming unequal variances).

4.2 EXPERIMENT

For the experiment, 20 participants were used in an attempt to verify the hypothesis. Of these participants, ten were placed in the open-labeled group ($n^o = 10$) and ten in the closed-labeled group ($n^c = 10$). In total, eight participants were between the ages of 10 and 20, eleven participants between 20 and 30 and one participant between 30 and 40. Eleven participants were male, while nine participants were female. Identically to the survey, participants of the experiment were asked how often they play video games in a week; on a 5-point scale (1 representing "never", 5 representing "a lot"), participants showed an average of 3.00 ($\sigma = 0.32$). Seven participants had heard of *World of Goo* prior to the experiment, while only three had ever played the game before.

As previously mentioned, participants were given ten minutes for the first MAT, ten minutes for playing *World of Goo* and ten minutes for the second MAT. The explanation of *World of Goo* (e.g. the game's goal, mechanics, controls) required approximately two or three minutes, while the filling in of the survey at the end took participants three to five minutes, putting the estimated total time required to finish the experiment around 40 minutes. In practice, however, all but one participants finished their MATs before the ten minutes had passed, with some being finished as soon as after five minutes. Furthermore, participants who managed to complete *Fisty's Bog* before ten minutes had passed were given the option to either replay the level (for a higher score) or continue to the next section of the experiment (note, however, that in general, participants required at least seven minutes to complete *Fisty's Bog*). Thus, for most participants, the experiment required between 25 and 30 minutes. Participants were offered candy or chocolate bars after completion of the experiment as reward.

The experiment results of both the open- and the closed-labeled groups are shown in **Table 4**, with the seven columns displaying (f. l. t. r.) (1) group, (2) number of participants (n), (3) mean score of MAT[1], (4) mean score of MAT[2], (5) mean absolute difference between MAT[2] and MAT[1]'s score (Δ) (standard deviation (σ) in brackets) and (6) p-values of the two-sample paired t-tests for means (two-tailed) used to acquire these results. A two-sample, unpaired t-test (two-tailed, assuming unequal variances) on both groups' absolute difference in mean MAT results provided a p-value of 1.

Group	n	MAT[1]	MAT[2]	Δ MAT	p
Open-	10	12.1	11.3	-0.8 (2.15)	0.27
Closed-	10	13.1	12.3	-0.8 (2.3)	0.3
Combined	*20*	*12.6*	*11.8*	*-0.8 (2.17)*	*0.12*

Table 4: Experiment results of the open- and closed-labeled groups, including mean absolute difference (Δ) in MAT results (standard deviation (σ) in brackets), as provided by two-sample paired t-tests for means (two-tailed).

Furthermore, relative change in MAT results was calculated for each individual participant. These results are visible in **Table 5**, which displays (f. l. t. r.) (1) group, (2) number of participants (n) and (3) mean relative change between MAT[2] and MAT[1]'s score (δ) (standard deviation (σ) in brackets).

Group	n	δ MAT
Open-labeled	10	-0.045 (0.17)
Closed-labeled	10	-0.039 (0.16)
Combined	*20*	*-0.042 (0.16)*

Table 5: Mean relative change (δ) in MAT results (standard deviation (σ) in brackets) of open- and closed-labeled groups, as provided by a two-sample unpaired t-test ($p = 0.93$, two-tailed, assuming unequal variances).

Mean grades given by both groups to *World of Goo* (on a scale of 1 to 10) can be seen in **Table 6**.

Group	n	Grade
Open-labeled	10	6.8 (2.57)
Closed-labeled	10	7.7 (0.67)
Combined	*20*	*7.3 (1.89)*

Table 6: Mean grade given to *World of Goo* (standard deviation (σ) in brackets) by open- and closed-labeled groups, as provided by a two-sample unpaired t-test ($p = 0.27$, two-tailed, assuming unequal variances).

Similar to the survey, results of the experiment were found to vary between female and male participants. These results are shown in **Table 7**. Note that an additional two-sample, unpaired t-test (two-tailed, assuming unequal variances) on both groups' absolute difference in MAT results provided a p-value of 0.0024.

Group	n	MAT[1]	MAT[2]	Δ MAT	p
Female	9	11.56	12.22	0.67 (0.87)	0.0497
Male	11	13.45	11.45	-2 (1.89)	0.0127

Table 7: Experiment results of female and male participants, including mean absolute difference (Δ) in MAT results (standard deviation (σ) in brackets), as provided by two-sample paired t-tests for means (two-tailed).

As with the open- and closed-labeled results, relative change (**Table 8**) and mean grades given to *World of Goo* (**Table 9**) between female and male participants were compared.

Group	n	δ MAT
Female	9	0.07 (0.08)
Male	11	-0.13 (0.14)

Table 8: Mean relative change (δ) in MAT results (standard deviation (σ) in brackets) of female and male participants, as provided by a two-sample unpaired t-test ($p = 0.0016$, two-tailed, assuming unequal variances).

Group	n	Grade
Female	9	7.8 (1.1)
Male	11	6.8 (2.3)

Table 9: Mean grade given to *World of Goo* (standard deviation (σ) in brackets) by female and male participants, as provided by a two-sample unpaired t-test ($p = 0.24$, two-tailed, assuming unequal variances).

As mentioned in paragraph 3.2.3, participants of the experiment were asked (after playing) whether they felt they had learned something from playing *World of Goo*. As shown in **Table 10**, most of the participants of the open-labeled group considered *World of Goo* to be able to educate them (to some degree), while participants of the closed-labeled group were divided on the game's ability to teach them something. Note that, while a chi-squared test was performed on **Table 10**, results did not meet the requirement, as (1) sample size ($n = 20$) and (2) (some of the) expected values (lowest: 3.5) were insufficient for a chi-squared test to be applicable.

	Open-	Closed-
Learned	8	5
Did not learn	2	5

Table 10: Response of open- and closed-labeled groups on whether they felt playing *World of Goo* had taught them something.

Based on their answer to whether or not they learned something from playing *World of Goo*, participants were divided into two groups, i.e. those who answered "yes" ($n^y = 13$) and those who answered "no" ($n^n = 7$). For both groups, mean absolute difference in MAT results (**Table 11**), relative change in MAT results (**Table 12**) and mean grades given to *World of Goo* (**Table 13**) were calculated.

Learned?	n	Δ MAT
Yes	13	-0.31 (1.97)
No	7	-1.71 (2.36)

Table 11: Mean absolute difference (Δ) in MAT results (standard deviation (σ) in brackets) of participants who did and did not feel *World of Goo* taught them something, as provided by a two-sample unpaired t-test ($p = 0.21$, two-tailed, assuming unequal variances).

Learned?	n	δ MAT
Yes	13	-0.01 (0.15)
No	7	-0.1 (0.16)

Table 12: Mean relative change (δ) in MAT results (standard deviation (σ) in brackets) of participants who did and did not feel *World of Goo* taught them something, as provided by a two-sample unpaired t-test ($p = 0.25$, two-tailed, assuming unequal variances).

Learned?	n	Grade
Yes	13	7.8 (1.2)
No	7	6.3 (2.6)

Table 13: Mean grade given to *World of Goo* (standard deviation (σ) in brackets) by participants who did and did not feel World of Goo taught them something, as provided by a two-sample unpaired t-test ($p = 0.19$, two-tailed, assuming unequal variances).

5. DISCUSSION

5.1 SURVEY

Results of the survey (as shown in **Table 1**) show that, when having to choose either a video game for educational purposes or one for entertainment, participants preferred to play a video game for entertainment. While the average preference for entertainment differs between the five sets of covers (as shown in **Table 2**), all sets produce a mean between 4 and 5, indicating a prominent preference for an entertainment-type video game over an educational one. Additionally, all one-sample t-tests (used on each individual set of covers and all of them pooled together) provided *p*-values below 0.05, indicating these results to be statistically significant.

However, these results do not automatically establish a dominant or prevalent animosity towards educational video games; that participants preferred to play a regular video game does not immediately mean they disliked the educational one. As mentioned, participants were asked to elaborate on their choice of preference: why would they rather play one over the other? By asking participants to explain their choice, some insight was given into their motivation.

For some participants, the mentioning of education was enough to cause an immediate negative response towards the (covers of the) educational video games. For example, one participant mentioned that words such as "exercises", "explanations" and "tasks" were off-putting. Similarly, multiple participants explained that they only chose the entertainment-type because the educational one showed "educational elements". In case of these participants (and their answers), a dominant, negative attitude towards anything educational was clearly present.

Other participants, however, did not necessarily exhibit a negative attitude towards education, but rather towards the act of learning with the use of a video game. Some explained that, while they would like to learn, a video game did not seem appropriate for them to learn with, showing a lack of faith or a lack of interest (or both) in the medium. Others stated that they deemed the medium to solely be for entertainment; if they were to play a video game, they would only do so to have fun and relax, not to learn.

Then there were those who responded negatively to some of the languages presented as educational content, but reacted positively to the other languages. For example, in the case of the educational video game featuring the (education of) German, a number of participants indicated that they did not feel like learning German, regardless of the medium. However, when presented with a video game with different educational content (e.g. Spanish), these participants exhibited an interest in playing, as this topic appealed to them. For these participants, their choice depended on the game's educational content, not necessarily on how they viewed education and / or video games (see

Table 2 for a comparison between the five individual languages).

Furthermore, some answers did not relate to education or video games at all. In this case, participants simply explained their choice by saying that one game seemed more "fun", "exciting" or "adventurous" than the other. Note, however, that these types of answers were scarce, as most related to one of the three categories mentioned above.

An interesting discovery while reviewing the survey's results was the fact that female and male participants showed quite a difference in mean preference. In particular, **Table 3** shows that female participants' preference is lower (consistently for each individual language and all of them pooled together) compared to male participants' preference, suggesting the female participants to be more tolerant towards the educational covers. While most two-sample unpaired t-tests used on these results provided p-values above 0.05 (e.g. $p = 0.67$ for German), the difference in mean preference of both sexes for the Russian cover appears to be statistically significant with a p-value of 0.02. Arguably more fascinating is the fact that the female participants' mean of 3.27 indicates a female preference for the (Russian) educational cover over the entertainment one. Considering that, for every other cover, participants of both sexes seemed to prefer the entertainment one, this difference in mean between female and male participants stands out. Lastly, mean preference of all covers combined provided a p-value of 0.01, suggesting the difference between female preference (3.96) and male preference (4.91) on the 6-point scale to be significant. While further research will be necessary in order to properly evaluate this difference, these results together suggest that on average, female participants seem to be more acceptant towards a game advertising educational content than male participants.

5.2 EXPERIMENT

Though results of the survey were able to provide some insight, results of the experiment proved to be more difficult to interpret. Nevertheless, the acquired data suggest three possibilities.

First, there is the possibility that awareness of educational intention does not have an effect on educational effectiveness of a video game. The use of two-sample unpaired t-tests on both groups' (1) absolute difference in MAT results (as shown in **Table 4**) and (2) mean relative change in MAT results (as shown in **Table 5**) provide high p-values of 1 and 0.93, respectively. As such, the results of the experiment do not allow for the null hypothesis – that there is no effect – to be rejected. Additionally, even if the p-value showed the results to be significant (suggesting an effect), absolute difference in MAT results of the open- and closed-labeled groups are identical, i.e. -0.8, further suggesting that conditions had no effect.

Second, it is possible that awareness of educational intention does have an effect on educational effectiveness, however this effect differs from what was hypothesized. While both show a relative decrease in MAT score after playing *World of Goo* (see **Table 5**), the open-labeled group shows a higher decrease (-0.045) compared to the closed-labeled group (-0.039). Although it was expected that, through playing *World of Goo*, participants' MAT results would improve rather than decrease, the difference in relative change could suggest the open-labeled condition to have a more negative effect than the closed-labeled condition. Nevertheless, the fact remains that, with the

aforementioned p-value of 0.93, the possibility of there being no effect at all is still just as credible. Alternatively, when dividing participants in two groups based on whether they felt they learned something from playing *World of Goo* or not (**Table 10**), the group of participants that felt they did learn something shows a lower decrease in absolute difference (**Table 11**) and relative change (**Table 12**) than the group of participants that felt they did not learn. While this experiment did not revolve around participants' evaluation of *World of Goo*'s educational ability, comparing these two groups brings to light the possibility that awareness of educational intention could also have a positive effect on a game's educational effectiveness (instead of a negative effect, as was expected in this thesis). However, current p-values of the two-sample unpaired t-test used to compare absolute difference ($p = 0.21$) and relative change ($p = 0.25$) between the groups are too high to establish any significant effect.

Third, it could be that while awareness of educational intention does affect educational effectiveness of a video game, the experiment of this thesis lacked the means to (accurately) show this effect. Particularly noticeable, for example, was how little the ten-minute (or less) playtime of *World of Goo* seemed to affect participants' mechanical aptitude. While I personally expect a correlation between the act of playing games such as *World of Goo* and improvement of players' abilities related to areas such as mechanical aptitude or spatial judgment, it has become obvious to me that extensive playtime is necessary for such a possible improvement to take effect. Although an indication of the average amount of time necessary for players to start learning and improving would (1) be difficult to determine and (2) differ immensely between games, players and educational topics, it is feasible to assert that, in case of this experiment revolving around the improvement of mechanical aptitude through play of *World of Goo*, players require at least several hours of playtime in order for a possible improvement in abilities to become noticeable. For this thesis, unfortunately, the means to orchestrate an experiment of such scale simply were not available.

Continuing the discussion of the experiment possibly lacking elements, another topic worth discussing is the possibility that *World of Goo* did not sufficiently fit the experiment's goal (i.e. establishing a difference in mechanical aptitude based on different conditions). Though *World of Goo* proved to be equally believable as both a regular video game and an educational one (of both groups, none of the participants questioned the game's true nature or intentions), the game's content might not be sufficiently educational. Considering how mean absolute difference (**Table 4**) and mean relative change (**Table 5**) of both the open- and closed-labeled groups all show a decrease in mechanical aptitude when comparing MAT[1] scores with MAT[2], it could even be argued that *World of Goo* might have had a negative effect on participants' mechanical aptitude. Although I personally suspect different causes for this decrease (see below), it could very well be the case that *World of Goo* might, at best, only slightly improve players' mechanical aptitude, yet fail to provide a significant improvement. If this were the case, the testing of players' mechanical aptitude before and after playing *World of Goo*, regardless of how much time they would be given to play the game, would still leave insufficient measurements with which to verify or disprove the hypothesis.

Alternatively, the MATs perhaps did not fit this experiment sufficiently. While the two MATs used for this experiment only contained questions on topics that, in some shape or form, appear in *World of Goo* (e.g. questions related to gravity or buoyancy), participants only played one level of the video game (i.e. *Fisty's Bog*) within a ten-minute-time span; as such, only some of these topics were presented to the participants, while others (such as momentum or the mechanics behind cogs and wheels) were featured in levels that the participants did not get to play and experience. Thus, a significant amount of the questions posed in both MATs revolved around topics that, while certainly present in *World of Goo*'s content, did not feature in the level participants played. Not surprisingly, a number of participants commented on this when asked if they felt like *World of Goo* taught them anything, stating that while they could imagine the game to be of some assistance when played longer, in this case it seemingly did not help with answering the questions.

Lastly, there is the possibility that the MATs used in the experiment were not designed properly. While the intention was to carefully group questions of both MATs in such a way that both would correspond to one another and have an equal level of difficulty, many participants remarked that they considered the two tests to be quite different. Further suggesting this notion that MAT^1 and MAT^2 did not correlate in relation to content and difficulty (and thus did not function as an effective, reliable method to establish difference in MA with) is the apparent difference in results between female and male participants. The absolute difference in MAT results, as shown in **Table 7**, appears to differ notably between sexes: female participants ($n^f = 9$) show a mean improvement in MAT score of 0.67, while male participants ($n^m = 11$) display a significant drop in score of -2. In a similar fashion, female participants' relative change in MAT results (**Table 8**) appears to be increasing (with an average of 0.07), while male participants (again) show a decline (with an average of -0.13). Both the two-sample paired t-tests used to establish means for female ($p = 0.0497$) and male ($p = 0.0127$) participants and the two-sample, unpaired t-tests (assuming unequal variances) used to compare the absolute difference ($p = 0.0024$) and relative change ($p = 0.0016$) between genders provided low p-values, suggesting these differences between sexes to be statistically significant in these cases. Seeing how, in relation to certain spatial abilities (e.g. spatial visualization ability), men and women differ in cognition (Robert & Chevrier, 2003), the cause for difference in MAT scores between sexes could be of similar origin. According to prior studies, in fact, gender appears to have a similar influence on mechanical abilities (Ringby, 2001). Looking back at **Table 7**, male participants showed a higher mean in score (13.45) compared to the female participants (11.56) for MAT^1, whereas the latter on average scored higher (12.22) than the former (11.45) on MAT^2. Although additional participants of both gender are necessary in order to accurately establish the actual cause for these differences, the above suggests that, in general, questions of MAT^1 were more suitable for male participants and questions of MAT^2 for female participants, thus preventing the two MATs from functioning as accurate tools to measure with in the experiment.

6. CONCLUSION

While through this thesis, I had hoped to determine whether *The Legend of Zelda: Ocarina of Time* would have given me the same amount of motivation to learn if the game had advertised itself as educational, it seems the results of the experiment are as of yet unable to answer this question.

Although the thesis' current data certainly does not support the hypothesis, I strongly believe further studies are necessary in order to accurately establish if transfer of a video game's educational content differs between conditions. In particular, I expect it to be necessary to (1) create a video game specifically for this experiment and (2) significantly increase the amount of time participants play this game before measuring a difference in aptitude or quality. While doing so would require more resources and time, it would allow for a more accurate and reliable method of assessing a correlation between awareness of educational intention and a video game's educational effectiveness. By designing a game solely for this purpose, it could be made sure that:

1. presentation-wise, the game can pose as both a game for education and one for entertainment, thus allowing open- and closed-labeled stimuli to be given at any time (instead of only giving these to participants before playing the game, as was the case in this experiment);
2. content-wise, the game can effectively educate players on an educational topic;
3. analysis-wise, to what extent the video game helped participants (of both conditions and of all sexes) improve their understanding of the educational topic can be accurately measured;

Alternatively, regardless of my reflection on what elements the experiment lacked, it could simply be the case that the awareness of educational intention does not affect the educational effectiveness of a video game. However, results of this thesis' survey suggest that many develop a negative attitude towards a video game when it reveals its intention is to educate, rather than entertain. While this negative attitude perhaps does not influence the game's educational effectiveness as hypothesized, it seems plausible to assume that it will not do the medium much good either.

In any case, it seems I will have to wait a little longer to find out if saving Princess Zelda would have been an equally powerful incentive to learn English if my Nintendo 64 kept reminding me I was being educated. Regardless, video games' capacity to enhance education in certain ways has become all the more clear to me during the making of this thesis. While the possible effects of video games on education have not yet been sufficiently researched, some of the medium's characteristics clearly show promise. However, for a new and effective form of education to be created with these characteristics, I expect it to be equally important to perform additional research on how different groups generally view education. If a negative attitude towards education is the primary obstacle preventing video games from becoming an effective tool to educate with, improving audiences' view on education would be a step in the right direction.

7. ACKNOWLEDGEMENTS

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8.2 MECHANICAL APTITUDE TESTS

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Note: a small number of questions in both Mechanical Aptitude tests created for this thesis were based on a test of unknown origin.

8.3 VIDEO GAMES

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Figure 1: Survey (paper version)

Enquête over verwachtingen van videospellen

Deze enquête is bedoeld om mij, Nesse van der Meer, student aan de Universiteit van Leiden, te helpen met het onderzoek van mijn masterscriptie voor de master Media Technology.

Op de onderzijde / achterkant van dit papier vindt u 10 verschillende afbeelding. Deze afbeeldingen zijn **voorkanten** ("**covers**") **van videospellen**.
De 10 afbeeldingen zijn opgedeeld in groepjes van twee: **Voorkant A** en **Voorkant B**. Voor elk groepje wordt u (op de andere pagina van deze enquête) gevraagd om de volgende vier vragen te beantwoorden:

① **Wat voor videospel zou u, gebaseerd op (de informatie die wordt gegeven op) de voorkant, verwachten als u naar Voorkant A kijkt?**
(bijvoorbeeld: wat voor soort spel, wat het doel is, wat voor taken u uit moet voeren etc.)

② **Wat voor videospel zou u, gebaseerd op (de informatie die wordt gegeven op) de voorkant, verwachten als u naar Voorkant B kijkt?**
(bijvoorbeeld: wat voor soort spel, wat het doel is, wat voor taken u uit moet voeren etc.)

③ **Welk videospel zou u, gebaseerd op (de informatie die wordt gegeven op) de voorkant, liever spelen?**
(u wordt gevraagd om dit aan te geven op een schaal van 6 punten; des te meer uw antwoord zich links bevindt, des te meer gaat uw voorkeur naar Voorkant A en des te meer uw antwoord zich rechts bevindt, des te meer gaat uw voorkeur naar Voorkant B)

④ **Waarom zou u liever het ene videospel willen spelen dan het ander?**
(oftewel: verklaar kort a.u.b. uw antwoord op vraag 3)

Let op: **er wordt niet gevraagd welke van de twee voorkanten u qua uiterlijk mooier vindt, maar welk spel u liever zou willen spelen**, gebaseerd op wat de voorkanten u over de spellen vertellen.
Naast bovenstaande vragen wordt u (**op de onderzijde / achterkant**) **van de pagina met vragen om wat persoonlijke informatie gevraagd**.

Raadpleeg a.u.b. geen externe bronnen (bijvoorbeeld het Internet, vrienden of familie) tijdens het invullen van deze enquête. De resultaten van deze enquête zullen gebruikt worden in een onderzoek naar videospellen. **Uw identiteit is en blijft anoniem** en uw antwoorden zullen exclusief voor het onderzoek gebruikt worden. Deze enquête zal u ongeveer 15 minuten kosten. Voor enige vragen of opmerkingen kunt u mailen naar: nessvdmeer@gmail.com.

<u>**z.o.z. voor de afbeeldingen;**</u>
<u>**u kunt deze pagina losmaken van het antwoordblad voor uw gemak!**</u>
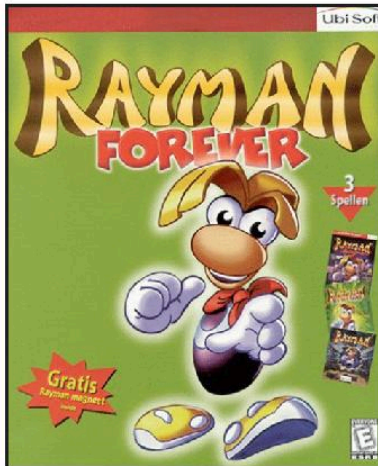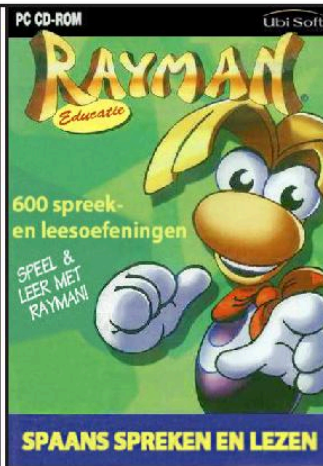
Voorkant **1-A** | Voorkant **1-B** | Voorkant **2-A** | Voorkant **2-B**
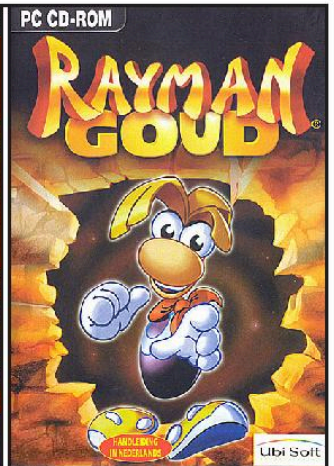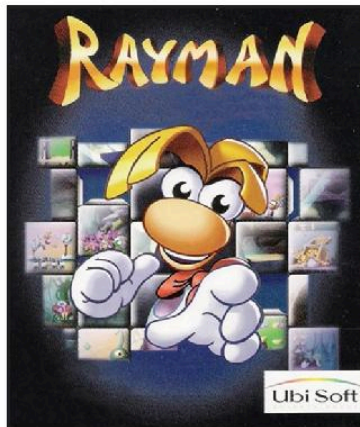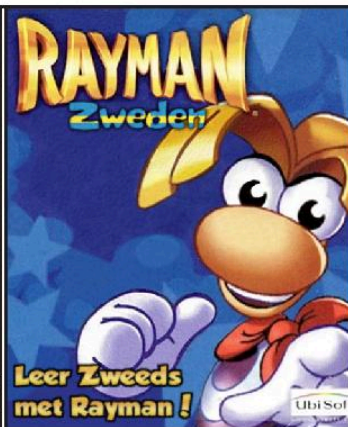
Voorkant **3-A** | Voorkant **3-B** | Voorkant **4-A** | Voorkant **4-B**
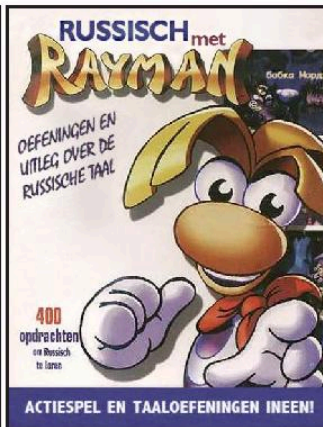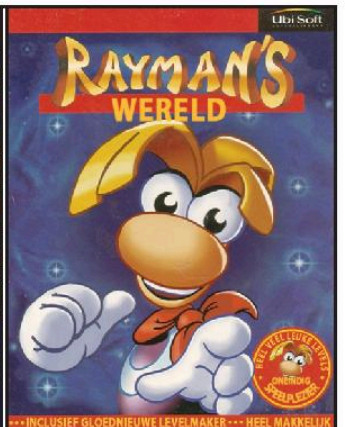
Voorkant **5-A** | Voorkant **5-B**

Bij **1-A** verwacht u een videospel waarin u:

① _____

Welk videospel zou u liever willen spelen?

1-A ❑ ❑ ❑ ❑ ❑ ❑ **1-B**

③ _____

Bij **1-B** verwacht u een videospel waarin u:

② _____

Waarom zou u het ene videospel liever dan het andere spelen?

_____

④ _____

Bij **2-A** verwacht u een videospel waarin u:

① _____

Welk videospel zou u liever willen spelen?

2-A ❑ ❑ ❑ ❑ ❑ ❑ **2-B**

③ _____

Bij **2-B** verwacht u een videospel waarin u:

② _____

Waarom zou u het ene videospel liever dan het andere spelen?

_____

④ _____

Bij **3-A** verwacht u een videospel waarin u:

① _____

Welk videospel zou u liever willen spelen?

3-A ❑ ❑ ❑ ❑ ❑ ❑ **3-B**

③ _____

Bij **3-B** verwacht u een videospel waarin u:

② _____

Waarom zou u het ene videospel liever dan het andere spelen?

_____

④ _____

Bij **4-A** verwacht u een videospel waarin u:

① _____

Welk videospel zou u liever willen spelen?

4-A ❑ ❑ ❑ ❑ ❑ ❑ **4-B**

③ _____

Bij **4-B** verwacht u een videospel waarin u:

② _____

Waarom zou u het ene videospel liever dan het andere spelen?

_____

④ _____

Bij **5-A** verwacht u een videospel waarin u:

① _____

Welk videospel zou u liever willen spelen?

5-A ❑ ❑ ❑ ❑ ❑ ❑ **5-B**

③

Bij **5-B** verwacht u een videospel waarin u:

② _____

Waarom zou u het ene videospel liever dan het andere spelen?

_____

④ _____

U bent een:

- ❏ Man
- ❏ Vrouw

Wat is uw hoogst voltooide opleiding?

- ❏ Geen opleiding
- ❏ Lagere school / basisonderwijs
- ❏ LBO, VBO, LTS, LHNO, VMBO
- ❏ MAVO, VMBO-t, MBO-kort
- ❏ HAVO
- ❏ VWO, Gymnasium
- ❏ HBO, HEAO, PABO, HTS
- ❏ Universiteit
- ❏ Anders, namelijk:

_____

Op wat voor platform speelt u voornamelijk videospellen? (Meerdere antwoorden zijn mogelijk)

- ❏ Computer (Windows, Mac, Linux)
- ❏ Laptop (Windows, Mac, Linux)
- ❏ Mobiele telefoon
- ❏ Tablet (iPad, Galaxy Tab, etc.)
- ❏ Mobiele spelcomputer (Nintendo 3DS, Game Boy, etc.)
- ❏ Spelcomputer (Xbox One, Wii U, Playstation 4, etc.)
- ❏ Geen van bovenstaande
- ❏ Anders, namelijk:

_____

Tot welke leeftijdsgroep behoort u?

- ❏ 5 - 10 jaar
- ❏ 11 - 15 jaar
- ❏ 16 - 20 jaar
- ❏ 21 - 25 jaar
- ❏ 26 - 30 jaar
- ❏ 31 - 35 jaar
- ❏ 36 - 40 jaar
- ❏ 41 - 45 jaar
- ❏ 46 - 50 jaar
- ❏ 51 - 55 jaar
- ❏ 56 - 60 jaar
- ❏ 61 - 65 jaar
- ❏ Ouder dan 65 jaar

Hoe vaak speelt u per week gemiddeld videospellen?

- ❏ Nooit
- ❏ Zelden
- ❏ Soms
- ❏ Regelmatig
- ❏ Vaak

In hoeverre bent u bekend met Rayman (het personage in deze enquête)?

- ❏ Niet - ik heb geen idee wie Rayman is
- ❏ Nauwelijks - ik heb wel eens van Rayman gehoord, maar de spellen nooit gespeeld
- ❏ Enigszins - ik heb wel eens een Rayman-spel gespeeld
- ❏ Aardig - ik heb meerdere spellen gespeeld
- ❏ Veel - ik ben een fan van Rayman en heb veel Rayman-spellen (uit)gespeeld

Heeft u één of meerdere Rayman-spellen die in deze enquête werden vertoond gespeeld?

- ❏ Ja
- ❏ Nee
- ❏ Weet ik niet

Dit is het einde van de enquête; dank voor uw deelname!

•

<u>Mechanisch Inzicht</u>

- Met deze test wordt uw (gemiddelde) mechanisch inzicht gemeten.

- De test bestaat uit **16 multiple-choice vragen**; **omcirkel op uw antwoordblad** voor elke vraag **het antwoord dat u denkt dat goed is**.

- Bij elke vraag zit een afbeelding die illustreert waar de vraag over gaat.

- **U krijgt precies 10 minuten om de test te maken. Stop a.u.b. direct met het maken van de test als aangegeven wordt dat de 10 minuten voorbij zijn**; het is niet erg als u niet alle vragen hebt beantwoord.

- Heeft u nog **vragen**? **Stel ze a.u.b. voor de test is begonnen**!

<u>Sla deze pagina a.u.b. pas om als de test is begonnen!</u>

1. Op welk touw valt meer gewicht?

a. Touw A
b. Touw B
c. Allebei evenveel

---
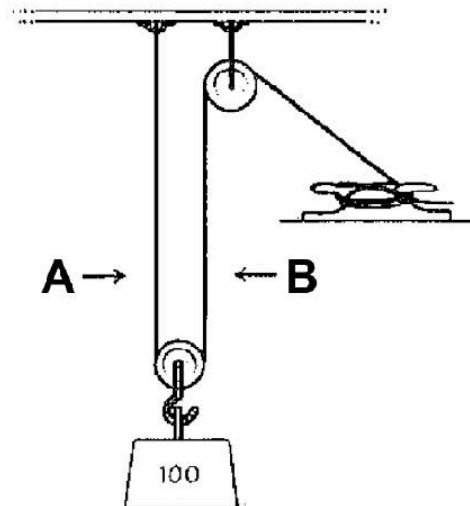
2. Op welke manier is de buidelzak makkelijker (minder zwaar) om te dragen als allebei de buidelzakken evenveel wegen?

a. Manier A
b. Manier B
c. Allebei hetzelfde

---
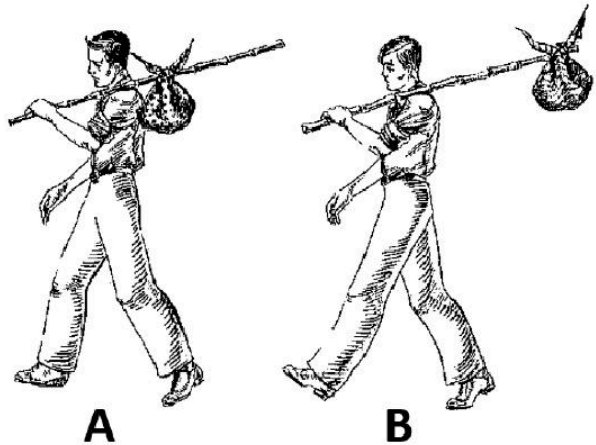
3. Welk tandwiel zal het meest ronddraaien in 1 minuut als het linkertandwiel draait?

a. Tandwiel A
b. Tandwiel B
c. Tandwiel C
d. Allemaal hetzelfde

1
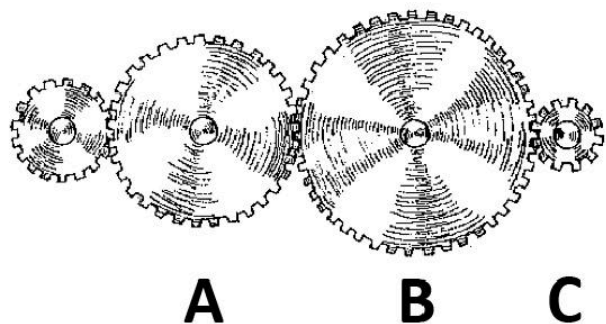
4. Welk wiel draait sneller als de kinderwagen naar voren wordt geduwd?

a. Wiel A
b. Wiel B
c. Allebei hetzelfde

---
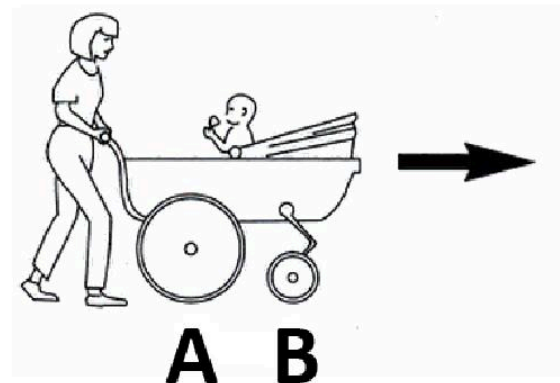
5. Allebei de acrobaten zijn even lang, even zwaar en even goed in balanceren; welke acrobaat zal het makkelijker vinden om in evenwicht te blijven?

a. Acrobaat A
b. Acrobaat B
c. Allebei hetzelfde

---
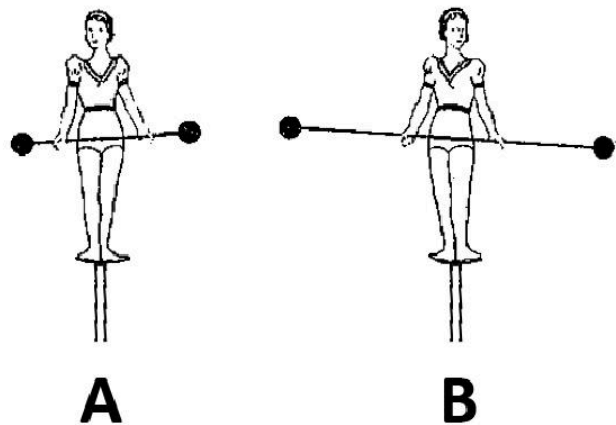
6. Allebei de vaten zijn even lang en even zwaar; welke man moet harder trekken om het vat naar hem toe te laten bewegen?

a. Man A
b. Man B
c. Allebei evenveel

2
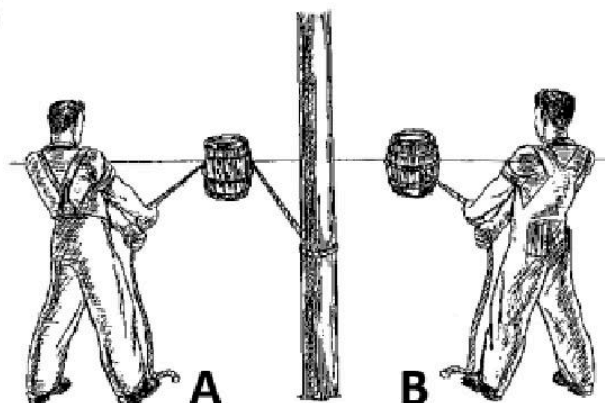
7. Als allebei de paarden even snel rennen, welk paard loopt dan achter als ze de bocht zijn uitgerend?

a. Paard A
b. Paard B
c. Allebei gelijk

8. Als het kleine tandwiel X tegen de klok in draait zoals aangegeven, in welke richting draait het grote tandwiel Y dan?

a. Richting A (tegen de klok in)
b. Richting B (met de klok mee)
c. Allebei mogelijk
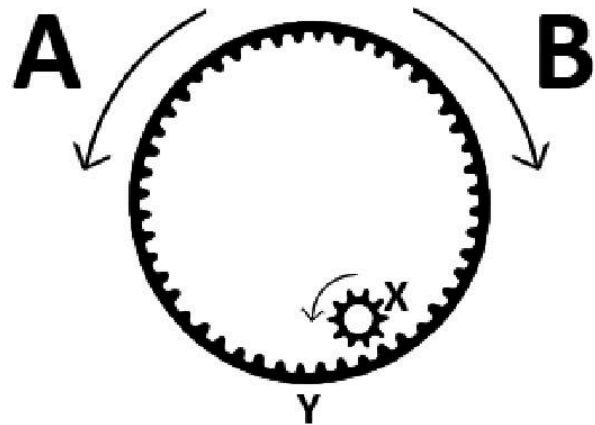
9. Op welke manier zou een bom vallen, als deze uit een bewegend vliegtuig wordt geworpen en er geen tegenwind is?

a. Manier A
b. Manier B
c. Allebei mogelijk

3
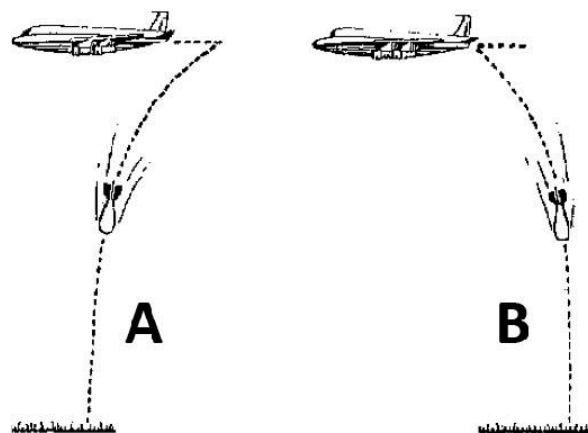
10. Welke passagier heeft een stabielere (rustigere) bootvaart, wanneer de boot door golven heen vaart?

a. Passagier A
b. Passagier B
c. Allebei hetzelfde
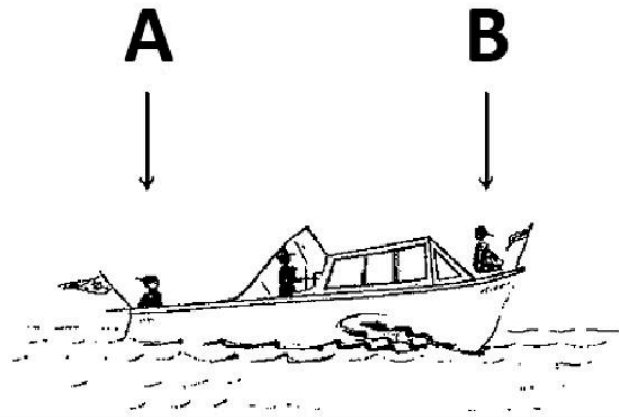
11. In de afbeelding is aangegeven in welke richting de ketting beweegt; welke wielen in de afbeelding draaien met de klok mee ("rechtsom")?

a. Wiel A, C en E
b. Wiel B, D en F
c. Wiel C en D
d. Wiel E en F
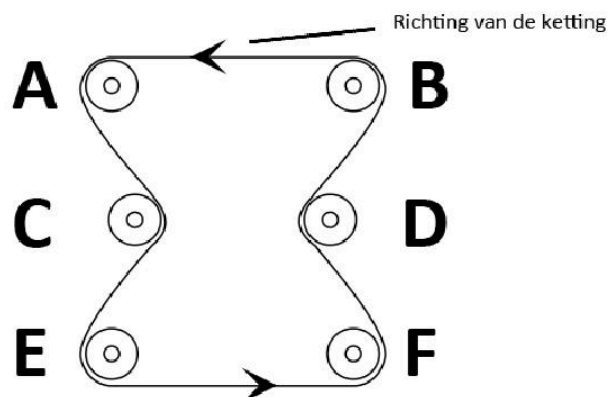
12. Welke ketting kan het best gebruikt worden om de brievenbus te ondersteunen?

a. Ketting A
b. Ketting B
c. Ketting C
d. Allemaal
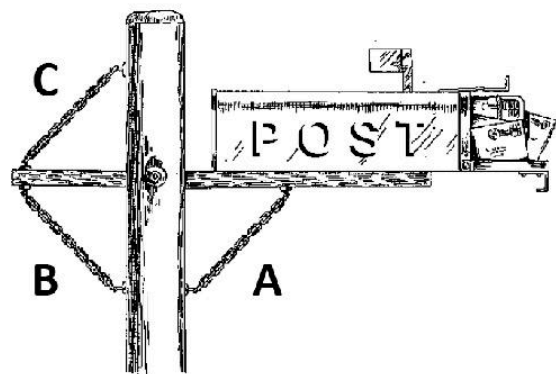
13. Als wiel W met de klok mee draait zoals aangegeven, in welke richting draait wiel Y dan?

a. Richting A
b. Richting B

4
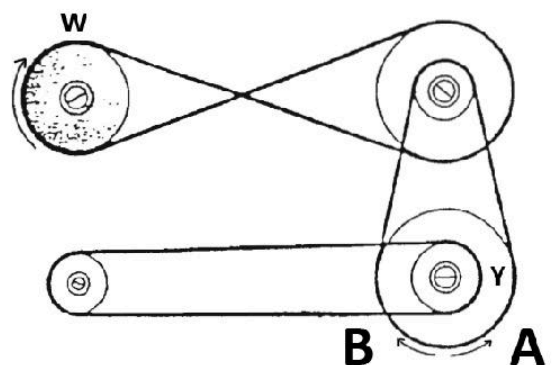
14. Beide lampen zijn even groot en even zwaar; welk touw zal eerder breken door het gewicht van de lamp?

a. Touw A
b. Touw B
c. Allebei evenveel
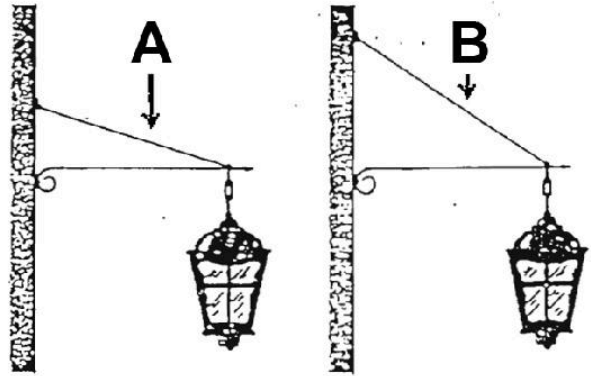
15. De winkelwagen wordt (met normale snelheid) in de richting van de pijl geduwd; opeens wordt de winkelwagen direct stop gezet. Naar welke kant valt het melkpak?

a. Kant A
b. Kant B
c. Het pak blijft staan
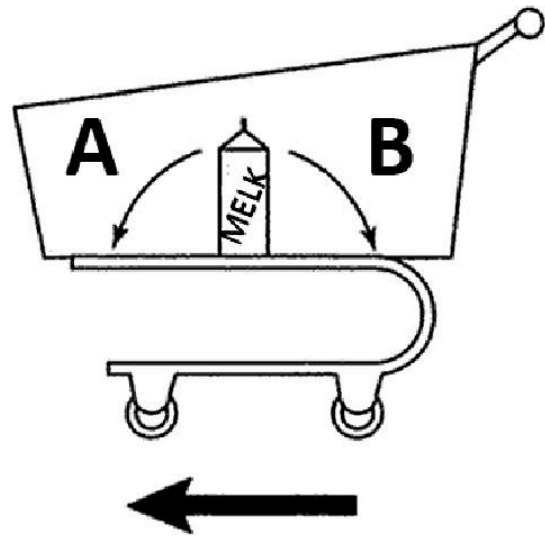
16. De slinger op de afbeelding zwaait heen en weer; op welk punt gaat de slinger het snelst?

a. Punt 1
b. Punt 2
c. Punt 3
d. Punt 4
e. Punt 5
f. Allemaal hetzelfde
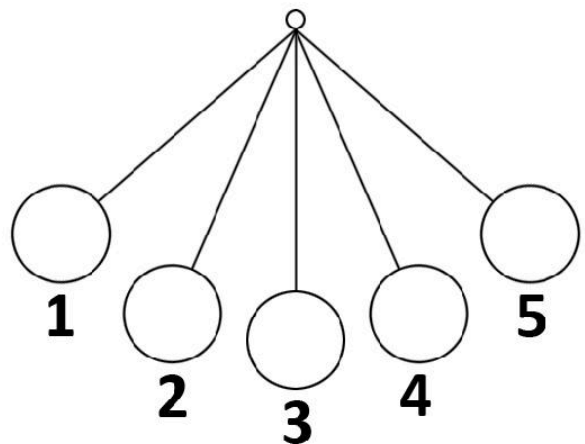
Dit is het einde van de test

Mechanisch Inzicht

- Met deze test wordt uw (gemiddelde) mechanisch inzicht gemeten.

- De test bestaat uit **16 multiple-choice vragen**; **omcirkel op uw antwoordblad** voor elke vraag **het antwoord dat u denkt dat goed is**.

- Bij elke vraag zit een afbeelding die illustreert waar de vraag over gaat.

- **U krijgt precies 10 minuten om de test te maken. Stop a.u.b. direct met het maken van de test als aangegeven wordt dat de 10 minuten voorbij zijn**; het is niet erg als u niet alle vragen hebt beantwoord.

- Heeft u nog **vragen**? **Stel ze a.u.b. voor de test is begonnen**!

Sla deze pagina a.u.b. pas om als de test is begonnen!

1. Welke tandwielen draaien tegen de klok in ("linksom") als tandwiel A ook tegen de klok in draait?

a. Tandwiel C en D
b. Tandwiel B en D
c. Tandwiel C en B
d. Tandwiel B, C en D
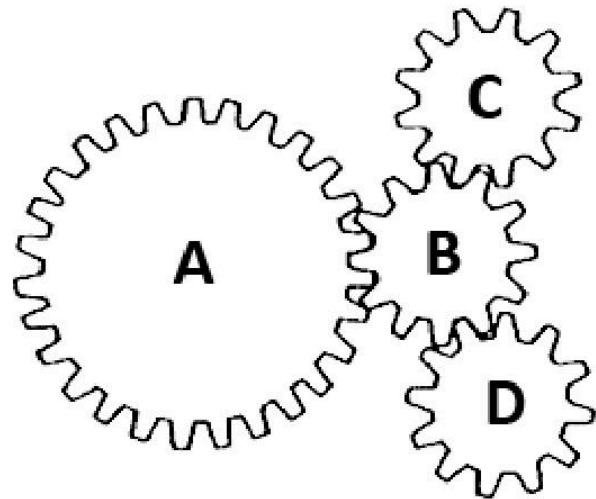
2. Welk gewicht zal als eerste opgetild worden als de man aan het touw trekt?

a. Gewicht A
b. Gewicht B
c. Allebei tegelijk

10 kg   20 kg
A   B
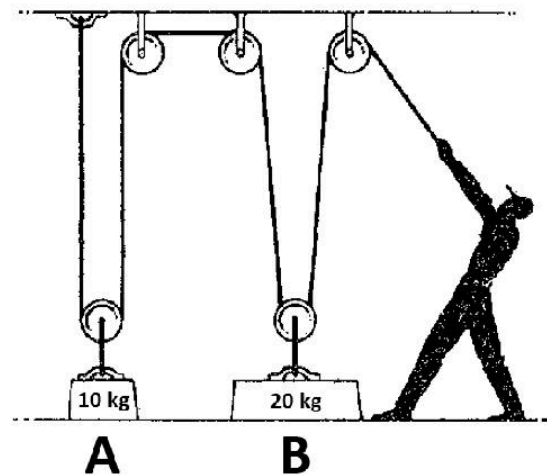
3. Welk wiel draait meer rond als iemand met de fiets gaat rijden?

a. Wiel A
b. Wiel B
c. Allebei evenveel

A   B

1
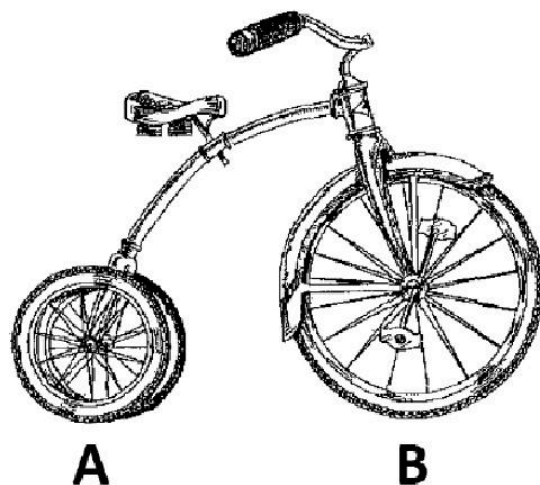
4. De drie houten ballen op de afbeelding zijn even zwaar en in alle drie zit een kleine, loden bal van dezelfde grootte (zie afbeelding). Welke houten bal rolt naar links?
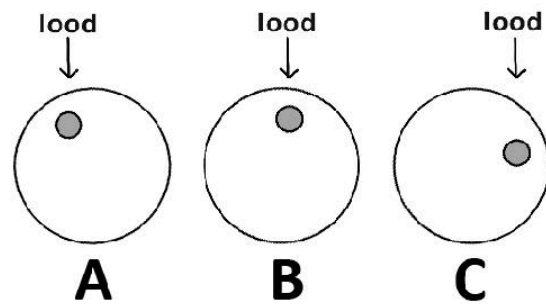
a. Bal A
b. Bal B
c. Bal C
d. Geen van allen

5. Welke man moet meer gewicht dragen?
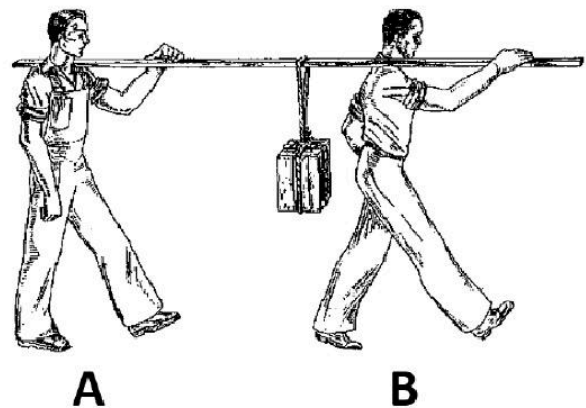
a. Man A
b. Man B
c. Allebei evenveel

6. Allebei de stenen zijn even zwaar en even groot; welke man moet harder trekken om de steen met zich mee te slepen?

a. Man A
b. Man B
c. Allebei evenveel

2
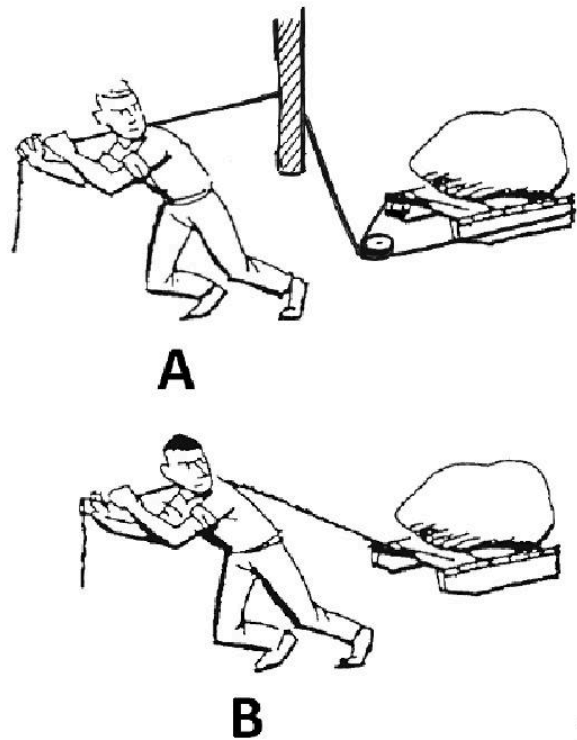
7. Als een wiel in de modder wordt gedraaid, op welke manier zal de modder dan van het wiel af vliegen?

a. Manier A
b. Manier B
c. Geen van beide
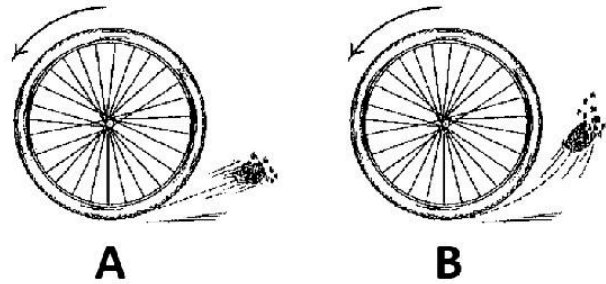
8. Het kleine tandwiel heeft 8 tanden; het grote wiel heeft 16 tanden. Als het grote tand wiel 12 keer (volledig) ronddraait, hoe vaak draait het kleine tandwiel dan (volledig) rond?

a. 8 keer
b. 16 keer
c. 24 keer
d. 32 keer
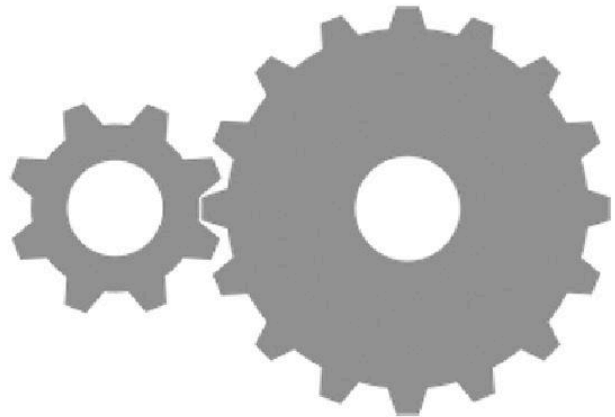
9. Welke wielen draaien tegen de klok in ("linksom")?

a. Allemaal
b. Wiel A, B, D en F
c. Wiel C en E
d. Wiel F en D

Richting van de ketting
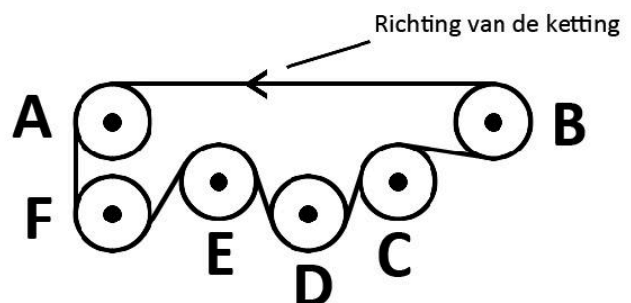
10. Rond een ster draaien twee planeten, A en B, met dezelfde snelheid. Welke planeet zal er langer over doen om helemaal rondom de ster te draaien?

● Planeet **A**

● Planeet **B**

Ster

a. Planeet A
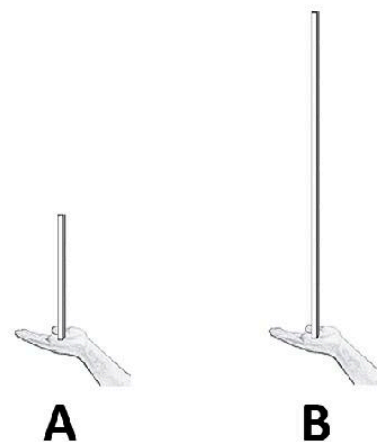b. Planeet B
c. Allebei even lang

11. Welke ketting kan het best gebruikt worden om de brievenbus te ondersteunen?

B

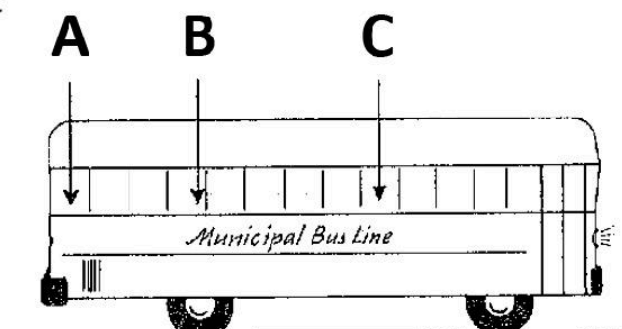post

A

a. Ketting A
b. Ketting B
c. Allebei hetzelfde
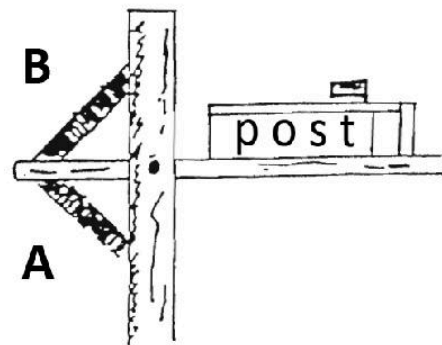
12. Welke stok is makkelijker te balanceren op je hand (welke zal minder snel omvallen)?
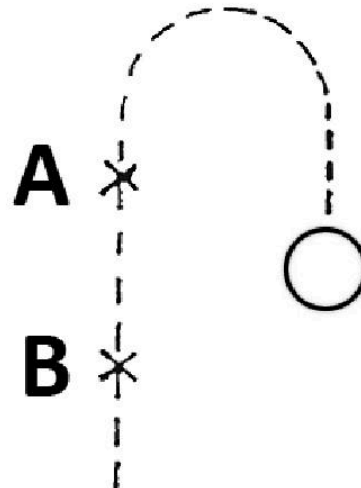
A   B

a. Stok A
b. Stok B
c. Allebei hetzelfde

13. Op welke plek heb je de meest stabiele busrit als de bus op een hobbelige weg rijdt?

A   B   C

Municipal Bus Line

a. Plek A
b. Plek B
c. Plek C
d. Allemaal hetzelfde

4

14. Een bal wordt omhoog gegooid, maakt een boog en valt weer naar beneden (zie afbeelding). Op welke plek beweegt de bal het snelst?
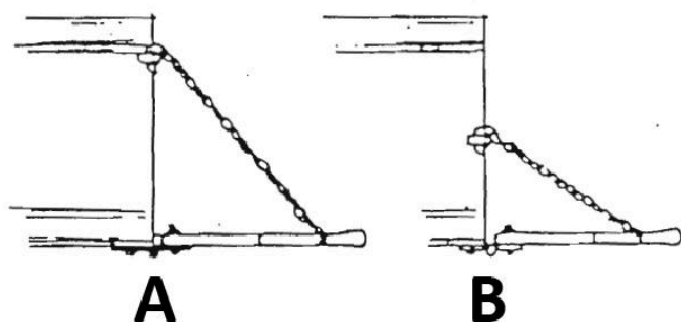
a. Plek A
b. Plek B
c. Allebei hetzelfde

15. Als het kleine tandwiel X tegen de klok in ("linksom") draait, in welke richting draait het grote tandwiel Y dan?

a. Richting A (tegen de klok in)
b. Richting B (met de klok mee)
c. Allebei mogelijk
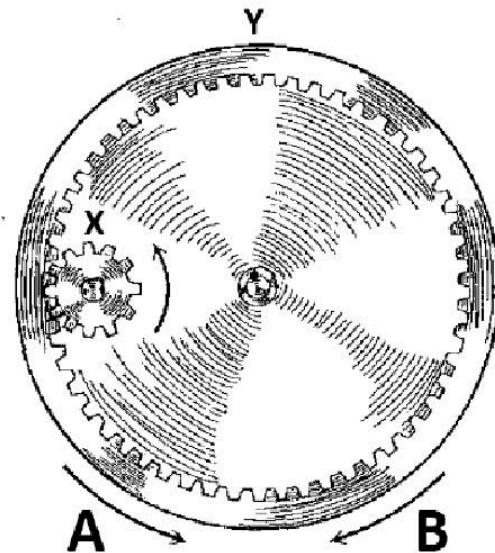
16. Welke ketting staat meer onder spanning?

a. Ketting A
b. Ketting B
c. Allebei evenveel

Dit is het einde van de test

Figure 3: Educational (top) and entertainment (bottom) variation of *World of Goo* cover