# Serious Games: Games That Facilitate Learning

***The effects of freedom and rewards in game based learning***

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## Introduction

The last decade has brought about many changes within the classroom. Initially education was based on teaching, such as lectures and classical instructions. Students used notebooks and ballpoints as common materials in the educational settings. Nowadays, notebooks and ballpoints have made way for newer materials such as computers, tablets and smartphones. This technological development has opened new opportunities for alternative learning strategies, causing a shift in the attention towards the use of computer games for learning and instructional settings, often referred to as 'game based learning' or 'serious games'. Reviews show that game based learning, otherwise known as GBL, can be more effective than conventional instructions (e.g. Sitzmann, 2011; Ke, 2009), due its entertaining aspect that are beneficial in terms of motivation and engagement (Erhel & Janet, 2013).

### *Computer Games*

Computer games can be defined as playful activities that have certain characteristics (Dempsey, Lucassen, Haynes & Maryann, 1996). The characteristics are the fundamental basis that provide a platform in which play is organized and structured. This can be done in many different ways, combinations and designs, resulting in a wide variety of games. According to the meta-analysis of the role of instructional support in game-based learning (Wouters & van Oostendorp, 2012), computer games can also be described as interactive (Vogel et al., 2006), based on a set of agreed rules and constraints (Garris et al, 2002), and directed toward a clear goal that is often set in the form of a challenge (Malone, 1981). It is crucial that the goal is clear in order to promote user engagement, since motivation is all about goal directed behaviour. Additionally, games constantly provide feedback either as a score or as changes in the game world, enabling players to monitor their progress towards said goal (Prensky, 2001). On top of that, computer games can implement challenging activities (Hannafin & Peck, 1988; Malone, 1981) choices (Hannafin & Peck, 1988), and fantasy elements (Lepper & Cordova, 1992). Moreover, Shute and Ke (2012) provided the features that a well-designed computer game contains, which are in line with the definition of computer games by Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013); (1) ongoing interactive problem solving; (2) specific goals or rules which help the player focus and stay motivated to play; (3) adaptive challenges which keep the level of difficulty of the game in and around the outer boundaries of players' ability—as the player gains new skills and becomes more capable the game's challenges become more difficult; (4) control by the player of game play, the game environment, and/or the learning experience; (5) ongoing and timely feedback; (6) uncertainty, which makes the game interesting, entertaining, and unpredictable; and (7) sensory stimuli which refer to the graphics, sound, and animation of the game, as well as a possible storyline which can keep the player interested or on

edge while progressing trough the game. Overall computer games have the same objective or goal namely to entertain the users that play the game.

*Serious Games*

Serious games, however, have a different goal. Where computer games are created to entertain the users, serious games are created with the objective to teach, train, inform or persuade (Annetta, Minogue, Holmes, & Cheng, 2009; Susi, Johannesson, & Backlund, 2007). Serious games combine the game characteristics and features for entertainment with instructional elements for learning, to enable learners to adapt learning to their cognitive needs and interest and providing motivation for learning (Malone, 1981). In serious games learners are supported by multiple methods and techniques that help to develop the learnings cognitive activities during gameplay for example: solving puzzles or problems in the game (Wouters & van Oostendorp, 2012). However, learning support, in combination with the game feature of the player's control of the gameplay, environment and or learning experience is somewhat conflicted. According to Black & Deci (2000), learning environments that allow for full control by the learner without explicit supports, can be more engaging and effective than learning environments without such freedom.

*The ARCS Model*

The ARCS model assumes that people will be motivated to engage in activities if they perceive a positive expectancy to be successful and that the activities are linked to the satisfaction of their needs (Cheng & Yeh, 2009). The model is used for improving the motivational appeal of instructional materials, in this case how serious games are designed. The ARCS model contains four conditions; (1) attention, (2) relevance, (3) confidence and (4) satisfaction (Keller & Kopp, 1987). These four conditions need to be fulfilled for people to become and remain motivated. Attention is element prerequisite for learning. The learner's attention needs to be stimulated and sustained in order to make learning effective. Unexpected events help sustaining the attention of learners. These events can be designed in game in order to arouse the learner's curiosity and interest (Cheng & Yeh, 2009). Relevance comes into play after attention is obtained. The learners are more likely to be motivated if the game content responds to their perceived needs. It comprehends how the subject matter or skills in games are thought. It is also necessary that the learners perceive an acceptable probability to succeed in order to keep them motivated. This expectancy for success is named confidence within the ARCS model. It influences the learner's persistence and achievement. Lastly, it is important that the learners feel good about the progress they made and whether the learners' efforts are consistent with their expectations. If their satisfaction is promoted by how much progress they made and the effort they had to put into it, they will continue to be motivated towards learning (Cheng & Yeh, 2009). One way

to do this in terms of serious gaming is by implementing rewards in the game. This subject will be discussed in depth later on.

*Intrinsic Motivation*

Intrinsic motivation occurs when the cause of motivation exists within an individual or task (Ormrod, 1999). It is a response of a spontaneous physiological need, personal curiosity and the strife for growth. Theorists claim that self-determination is an innate characteristic of intrinsic motivation (Deci & Ryan, 1985). Self-determination refers to the idea that people want to believe they can choose to engage in activities of their own willingness. People who feel self-determined have thoughts such as 'I want to do something' rather than 'I have to do something'. Individuals who feel self-determined, are more like to engage in tasks for a longer period of time, will think more meaningfully about the task, will find more pleasure in such tasks and make greater achievements when the circumstances confirm their feelings of self-determination (Deci & Ryan, 1987). Deci and Ryan found that mastery, autonomy and relatedness are connected with intrinsic motivation. Mastery refers to the users feeling of confidence about their knowledge or ability within the specific context. The feeling of mastery of a skill can drive the user's engagement within the game. Autonomy refers to the freedom users have within the game, whether users feel they are in control. That they can to choose their own paths within the game rather than playing trough it in the way someone desires. Finally, relatedness refers to the feeling that the user is not alone. That there are also other people who are engaged in the same game. This feeling can help the user feel better about the gaming task at hand.

*Import aspects of games that influence motivation*

Gamification is the use of gaming aspects and playful aspects to help the user find a personal connection that motivates engagement within a specific context. Nowadays the word 'gamification' has become inseparable with rewards. Gamification systems focus on adding points, on levels, leader boards or achievements, in order to entice people to engage with the specific context to earn these rewards (Nicholson, 2015). Many reward-based gamification systems create an immediate increase in engagement, as users strive to explore this new system. Users motivated to earn these rewards can continue to play the game as long as the rewards can be earned. However, if the supply of rewards are stopped, the behaviour of playing the game can also stop with it (Nicholson, 2015). Reward-based gamification systems can be valuable if the users do not develop intrinsic motivation to play the game. Deci and Ryan found in their studies about motivation that extrinsic rewards replace intrinsic behaviours (2004). This means that if rewards are implemented in a game to encourage engagement while the user already had some intrinsic motivation to engage with the game, then removal of these rewards can cause the user to be less likely to engage in the game than when he or she began.

Another important aspect of gamification is freedom. There are two types of freedom within gamification. The first is freedom of choice, which gives the users control within the game. This is a way to soften the required engagement in the game, by enabling users to freely explore within the game. Users have a more positive sense of self-being if he or she has autonomy within the game. (Nicholson, 2015). The most common implementation of freedom of choice within games is to let the users decide what activities they want to do in the game. The second type of freedom is the freedom to fail. This encourages the player to experiment within the game without the fear of causing irreversible damage. In practice this freedom can be achieved by implementing check points throughout the game or by giving the player multiple lives.

Incorporating such freedom in a classroom design is an effective dynamic to increase student engagement, as students are encouraged to take risks and experiment when the focus is taken away from the main goal and re-centred on the process of learning instead (Stott & Neustaedter, 2013). Moreover, to maintain player engagement, a player must feel in control in the game, rather than feeling controlled by the game and a set path. The element of freedom effectively enables users to choose their own path throughout the game, resulting in increased engagement.

The aim of this paper is to explore whether the aspects of freedom and rewards of gamification have a positive effect on learning. It is expected that these aspects of gamification foster motivation and thus promotes learning.

H1: *Freedom in serious games promotes the user's motivation to play the game.*

H2: *Rewards in serious games promotes the user's motivation to play the game.*

## Methods

### *Design*

An experimental 3 design pre-post-test was used to test the hypothesis. The independent variables are: (a) freedom and (b) rewards. Participants were divided across three conditions: (a) freedom, (b) rewards and (c) freedom and rewards. In condition (a) freedom, participants could select any level in the game from the start. In condition (b) rewards, participants could only play the next level if the previous level was completed. Also, they also were rewarded with stars and points after completing a level. In the last condition (c) freedom and rewards, participants could play any level from the start of the game and were rewarded upon completion of the levels with stars and points. In each condition participants had to fill in a pre-motivational questionnaire before playing the game and a post-motivational questionnaire and post-test on logical gates knowledge after playing the respective game condition.

*Participants*

The participants in this research are psychology students from the University of Twente. They were chosen by opportunity sampling by using the SONA platform, where psychology students willing to participate can sign up to take part in the research as long as the research is open on this platform. It is expected that psychology students do not have prior knowledge about the subject matter 'logical gates'. The 45 participants are of ages between 18 and 24 years old, of which 29 are male and 16 are female.

*Materials*

Several materials were needed to conduct the test. First, in the preparation process, a serious game has to be designed. This was done in the platformer and creator game "LittleBigPlanet 3" on the PlayStation 4. Five levels were designed by using the level creation platform and tools within this game. The levels scale from easy to hard playing difficulties. Participants all started in the "hub", which is the introductory environment of the game, where participants could pick the level they are going to play.


*Figure 1. The Hub, Players could open a level by pressing the button on top of the wooden box in front of the level portraits.*

Three levels consisted of puzzles about logic gates. These puzzles were always shown on a white board in the level environment. The goal of the puzzles was to change the green '✗'mark to a green '✓' mark on the right side of the white board. This could be done by changing the input signal from 0 to 1 or vice versa on the left side of the white board. A '✗'mark represented no signal or a 0 while a '✓' mark represented a positive signal or a 1. The input signal could be changed by pressing buttons, switching levers or either moving objects depending on the level the participants were playing. For example, a correct solution is presented in figure 3. By moving the blue cubes into the holes with buttons, changed both the boxes on the left side of the white board from a '✗' mark to a

‘✓’ mark. Thus changing both the inputs of the AND gate from 0 to 1 resulting in a positive output signal of the AND gate that led to a change of box on the right side from a ‘✗’ mark to a ‘✓’ mark. This opened a door on the right side of the screen which led to the next puzzle.

One level consisted of a mini-game, which is a short game within the original game, that differs from the rest of the game, where participants had to push the correct combination of coloured buttons based on the logic gate they were shown, in combination with the coloured boxes on the bottom of the screen, until there time was up. Pressing a coloured button changed the respectively relevant coloured ‘✗’ mark to a coloured ‘✓’ mark on top of the screen (see figure 2). While a AND gate was shown on the white board in the middle of the screen, participants had to press both of the coloured buttons corresponding to the colors shown on the bottom of the screen. While the X-or-Gate was shown, players had to press one of the colored buttons corresponding to the colors shown on the bottom of the screen and wait for 3 seconds. For every consecutive correct trial a ‘I’ was added to the streak on the right side of the screen. In the (b) rewards condition and (c) rewards and freedom condition these consecutive streaks gave points after each correct trial (‘I’ times 10 points). For example in figure 2 is a AND shown on the white board in the middle of the screen. On the bottom of the screen two boxes are coloured, namely red and yellow. The correct soloution would have been to change both the red and yellow ‘✗’ mark to a to a ‘✓’ mark by pressing the yellow button and the red button. In figure 2 the yellow button is already pressed by the player.

At last a “boss fight”, which was the hardest level, was created. Boss fights are often the hardest parts in video games. Players typically face a nemesis in boss fights. Whom players have to defeat to successfully complete a boss fight level. In this serious game, participants had to give the correct combination of pressing buttons in the same manner as the previous levels in order to solve the logic gate puzzles shown in the white board in the middle of the screen (see figure 4). Only this time the participants were time pressured. When a faulty input was given when their time was up, the participants lost one of their lives. Participants failed the level when they lost all three of their life’s, and successfully cleared the boss fight after the participants successfully solved ten puzzles.


*Figure 2. Minigame were players had to press the correct color combinations coresponding to either an AND gate or a X-or-gate.*

Three conditions were created of this game. In the first condition participants had no freedom within the game. They had to play the levels from level 1 to level 5 and thus could only progress within the game by completing the previous level (see figure 5).

*Figure 3. A player solved the first puzzle in level 1 by pushing the blue cubes into the holes with*


*Figure 4. The boss fight level. Participants had to press the coloured buttons in order to change the signals of the corresponding coloured inputs in the logical gate puzzle.*


*Figure 5. The Hub in the "no freedom' condition. The levels are locked and could only be opened after completing the previous level.*

In the second condition participants could only progress within the game by completing the previous level however rewards were given based on the performance of the participants. These rewards consisted of in-game points and in-game medals. The in-game medals consisted of stars shown above the level portraits in the hub (see figure 6). Six golden stars represented a perfect score, while three silver stars represented a good performance and one bronze star represented a mediocre performance. However, participants rewarded with one bronze star still successfully solved the puzzles of a level eventually.


*Figure 6. A Player being awarded with 5 gold star medals and 3000 points after completing level 1.*

In the last condition participants had the freedom the play the levels they wanted to play. They did not have to complete previous levels in able to progress within the game. They also were rewarded with in-game points and in-game medals based on their performance. To be able to let participants play the three conditions of the game an computer screen was needed along with a HDMI cable connected to a PlayStation 4. Also a PlayStation 4 controller was needed along with the CD of

the game "LittleBigPlanet 3". An informed consent was needed to be signed in order to let participants participate in the experiment. At last three questionnaires were used in order to collect data. These were a test to measure content knowledge about logical gates, a questionnaire about initial motivation from Rheinberg, Vollmeyer and Burns (2001), the same questionnaire about motivation transformed to the past tense. These questionnaires measures motivation on four factors, namely (1) probability of success, (2) anxiety, (3) interest and (4) challenge.

*Table 1*

*Four factors that measure initial motivation and example questions that measure these four constructs*

| Factors | Example Questions |
|---|---|
| *Probability of succes* | I probably won't manage to do this task. |
| *Anxiety* | I'm afraid I will make a fool out of myself. |
| *Interest* | I like riddles and puzzles. |
| *Challenge* | I am eager to see how I will perform in the task |

*Procedure*

In the experimental process, the participants were first instructed verbally about the game they were going to play. Then they had to fill in a short questionnaire about motivation from Rheinberg, Vollmeyer and Burns (2001) (*Appendix 1*). Afterwards the participants were instructed to the play the designed serious game about logical gates on the PlayStation 4 for 30 Minutes. The researcher picked and started the game in one of the three conditions. Further instructions about the button layout on the controller were given verbally to the participants. Afterwards the participants had to fill in another questionnaire about motivation by Rheinberg, Vollmeyer and Burns (2001) which was presented in past tense (*Appendix 2*) and the test about logical gates (*Appendix 3*). The data from all the questionnaires were put into tables and analysed.

*Data analysis*

The data was analyzed through the use of SPSS v24 (2017). First, the descriptive statistics (means, standard deviations, standard error mean) will be presented. Second, a Shapiro-Wilkon test will be used in order to determine whether the data is normally distributed. When the data is normally distributed, an ANOVA-analysis will be conducted. When the data is not normally distributed, a Kruskal-Wallis analysis will be conducted, to account for the non-normally distributed data

**Results**

*Table 2*[1]

*Descriptive statistics of the pre motivation constructs*

| Condition | | Challenge Score | Interest Score | PoS Score | Anxiety Score |
|---|---|---|---|---|---|
| Freedom | Mean | 4,6861 | 5,8800 | 5,1528 | 2,0889 |
| | N | 15 | 15 | 15 | 15 |
| | Std. Deviation | 1,02509 | ,92999 | ,97776 | ,70920 |
| Rewards | Mean | 5,1917 | 4,4956 | 4,5694 | 2,7111 |
| | N | 15 | 15 | 15 | 15 |
| | Std. Deviation | ,98725 | 1,15146 | ,93973 | 1,28611 |
| Rewards and freedom | Mean | 4,3167 | 5,0867 | 4,6861 | 3,3800 |
| | N | 15 | 15 | 15 | 15 |
| | Std. Deviation | ,72457 | ,60590 | 1,06578 | 1,25406 |
| Total | Mean | 4,7315 | 5,1541 | 4,8028 | 2,7267 |
| | N | 45 | 45 | 45 | 45 |
| | Std. Deviation | ,97112 | 1,06906 | 1,00576 | 1,21284 |

*Table 3*[1]

*Descriptive statistics of the post motivation constructs*

| Condition | | PostChallenge Score | PostInterest Score | PostPoS Score | PostAnxiety Score |
|---|---|---|---|---|---|
| Freedom | Mean | 5,6389 | 6,2378 | 4,9389 | 2,1511 |
| | N | 15 | 15 | 15 | 15 |
| | Std. Deviation | 1,06121 | ,63881 | 1,00110 | 1,21072 |
| Rewards | Mean | 4,6472 | 4,9933 | 4,6278 | 2,8511 |
| | N | 15 | 15 | 15 | 15 |
| | Std. Deviation | 1,37011 | 1,39666 | ,94746 | 1,06368 |
| Rewards and freedom | Mean | 4,9000 | 4,8067 | 4,2000 | 3,2089 |
| | N | 15 | 15 | 15 | 15 |
| | Std. Deviation | ,83375 | ,78782 | ,93411 | 1,06514 |
| Total | Mean | 5,0620 | 5,3459 | 4,5889 | 2,7370 |
| | N | 45 | 45 | 45 | 45 |
| | Std. Deviation | 1,16527 | 1,16648 | ,98792 | 1,17676 |

[1] The scores per construct are between 1 and 7. 7 indicates the highest possible score, where 1 indicates the
lowest possible score.

To gain general insight into the collected data and thus the three conditions, the descriptive statistics are shown in table 2 and 3. Table 2 shows the descriptive statistics of the pre scores of the motivation constructs and table 3 shows the post scores of the motivation constructs. Importantly, the answers of questions 3 and 13, measuring the construct probability of success, needed to be altered, so a higher score on the question would also indicate a higher score on the construct.
Since the research was conducted with a relatively small sample size (n=45), a test was needed to determine if the collected data is normally distributed. A Shapiro-Wilkon test was conducted, and showed that the pre and post scores for most constructs are not normally distributed ($p<0,05$). However, both post scores for the constructs anxiety and challenge were normally distributed ($p=0,852$; $p=0,726$) in the rewards condition.

To determine whether the difference between the pre and post scores per construct are normally distributed, the Shapiro-Wilkon test was conducted. The difference in score of the construct "challenge" was normally distributed in the reward condition and in the reward & freedom condition ($p=0,597$; $p=0,569$). Also, the difference in the score of the construct "anxiety" was normally distributed in the freedom condition ($p=0,847$) Finally, the difference in the score of the construct "interest" was normally distributed in the freedom condition ($p=0,596$).

Finally, Kruskal-Wallis H Test was conducted to determine where there are differences between conditions in regards to the post scores. The Kruskal-Wallis H Test showed that there was no significant difference in post-challenge scores, $\chi^2(2)=4,904$, $p=0,086$ with a mean rank post-challenge score of 29,00 in the freedom condition, 19,10 in the rewards condition and 20,9 in the rewards & freedom condition. Also, there is no significant difference in post-probability of success scores, $\chi^2(2)=4,465$, $p=0,107$ with a mean rank post-probability of success scores of 27,87 in the freedom condition, 23,33 in the rewards condition and 17,80 in the rewards & freedom condition. However, there is a significant difference in post-interest scores between the three conditions, $\chi^2(2)=15,742$, $p<0,0005$ with a mean rank post-interest score of 33,73 in the freedom condition, 19,37 in the rewards condition and 15,9 in the rewards & freedom condition. Also, a there is significant difference in post-anxiety scores between the three conditions, $\chi^2(2)=7,122$, $p=0,028$ with a mean rank post-anxiety scores of 15,93 in the freedom condition, 24,73 in the rewards condition and 28,33 in the rewards & freedom condition.

To determine if the collected test data is normally distributed. A Shapiro-Wilkon test was conducted, and showed that the scores of the logical test are not normally distributed ($p<0,05$). The Kruskal-Wallis H Test showed that there was no significant difference in test scores, $\chi^2(2)=0,114$, $p=0,945$ with a mean rank test score of 22,13 in the freedom condition, 23,73 in the rewards condition and 23,13 in the rewards & freedom condition

*Table 4*
*Descriptive statistics of the logical gate test*[2]

| Test_Score | | | |
|---|---|---|---|
| Condition | Mean | N | Std. Deviation |
| Freedom | 4,2000 | 15 | 2,90658 |
| Rewards | 4,4333 | 15 | 2,66000 |
| Rewards and freedom | 4,2500 | 15 | 3,04871 |
| Total | 4,2944 | 45 | 2,81195 |

**Discussion**

The results indicate that the gamification aspect of freedom has a positive effect on users and engagement and therefore, in learning. Accordingly, the participants were more interested after playing the game in the freedom condition. Even though the average post scores for the construct interest were lower than the pre score, the participants scored significantly higher on interest than the participants in other conditions. However, participants significantly scored the lowest on the construct of interest, when freedom was paired with rewards. Even though the participants in said condition on average had a low score for interest, the results show that their interest did grow after participating in the gaming process. The participants in the rewards condition generally had a higher score on interest than those in the rewards & freedom condition, but these participants seemed to lose interest after participating in the game. However, the results show that this decline in interest is minimal.

Regarding the construct anxiety, the following can be stated. Participants in the freedom condition significantly had the lowest scores on anxiety. However, participants significantly showed the highest scores on anxiety when freedom was paired with rewards. Also, participants in the freedom condition showed lower anxiety after participating in the game, whereas participants in the rewards & freedom condition showed a higher score in anxiety. These changes are significant, however relatively small.

The results show higher scores for the constructs challenge and possibility of success for participants in the freedom condition, however these scores are not significant. Participants in the rewards & freedom condition scored the lowest scores on three of the four constructs, with the exception of the construct challenge. The participants that scored the lowest on the construct of challenge, were in the rewards condition. However, said scores regarding the challenge construct are not significant.

All in all, freedom scores the highest on all four constructs, indicating that participant motivation is the highest in that condition, which enhances user engagement. Even though the

[2] A maximum of 15 points could be scored in the logical gate test.

participants showed a minimal decline in interest after participating in the game, they showed less anxiety, challenge and more probability of success. The participants in the freedom condition score higher than the other conditions on every construct. Concluding that hypothesis 1, stating that freedom in serious games promotes the user's engagement to play the game, can be accepted.

Regarding the second hypothesis, that rewards promote the users engagement to play the game, the following can be stated. The participants in the rewards condition did not show any improvement in the scores regarding challenge, interest and possibility of success after participating in the game. The only construct that showed improvement, is anxiety and this difference in score in relatively small. Also, the participants in this condition scored average, with exception of the construct challenge where they had the lowest score between conditions. Based on this information, hypothesis 2 can be rejected.

Combining freedom and rewards results in the lowest scores on all constructs, with the exception of the construct challenge. However, the scores do show minimal improvement compared to the pretest on the constructs of probability of success, challenge, and interest.

The results on the post test of the freedom condition show a decline in the scores of the construct, challenge. This can be explained by the fact that participants can choose the level, and thus the difficulty of the game. This results in the participants feeling less pressure, as they can learn the new skill required by the game at their own pace. Accordingly, the feeling of less pressure felt by the participants results in a lower score on the post test of the construct anxiety as well. However, it must be stated that the decline in scores of anxiety are minimal. Moreover, because participants can assess their own skills in the freedom condition, the rise in scores on the construct, probability of success can be explained.

However, when participants only received rewards and had no freedom, the scores on the posttest are lower regarding the construct, probability of success and higher on the construct, challenge. The participants received feedback in the form of scores about their performances. When the feedback was not as they hoped, in the form of a low score, the participants could have felt pressure, as they moved on to the next level. The participants had no freedom, thus could not choose the difficulty of the level they wanted to play, to possibly improve their score, resulting in a feeling of challenge and low probability of success.

When looking at the condition where the participants had freedom and received rewards, the scores on the post-test regarding the construct challenge are lower and the scores on the probability of success are higher, which is in line with the interpretation of the effect of the freedom condition. These differences were not as large as in the freedom condition.

The fact that the game was played on the PlayStation could have had an effect on the data, in the sense that not all participants were familiar with the controls of the console. This could have resulted in higher scores on challenge and lower scores on probability of success, as there also might have been a challenge in controlling the PlayStation itself. This could have a negative effect on the learning

of the subject matter, as most participants who were not entirely familiar with the controls of the console, had to learn this first in order to properly participate. This was noticeable as participants asked questions about how to control the game or where certain buttons where located, even though the controls were explained and dictated by matter of text on the bottom of the screen throughout the game.

The aforementioned can also possibly explain the low test scores on the logic gates test. Another explanation for the low scores can be that the test was too difficult. The data showed that the test was indeed too difficult, as the participants scored very poorly. This could have been prevented by doing a pilot test. However, due to time constraints this was not a possibility. A few participants did show high scores on the logic gates test, and as such these subjects are expected to have prior knowledge of the subject matter. The participants that scored noticeably higher than the average, are expected to have prior knowledge of the subject matter. However, test to measure prior knowledge could affect the data negatively. During the test the participants become aware of what is expected from them. Participants may take a more critical stance towards learning the subject matter during the game.

In the future, to improve comparable researches, it can be recommended to make the program as such that it occupies a longer period of time. This way participants have more time to become familiar with the controls of the respectively relevant console, and thus can focus better on the learning of the subject matter. On top of that, it might be better that participants take a test that measures prior knowledge to the subject matter and a post test on the subject matter, so a better statement can be made about whether the influence of these gamification aspects has an impact on learning, instead of making assumptions about learning based on participant's motivation.

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*Appendix 1*

Name: …….. Date:

……..

Age:…….

Gender: ……

Questionnaire 1

| | | disagree | | | | | | agree |
|---|---|---|---|---|---|---|---|---|
| 1 | I like riddles and puzzles. | O | O | O | O | O | O | O |
| 2 | I think I am up to the difficulty of this task. | O | O | O | O | O | O | O |
| 3 | I probably won't manage to do this task. | O | O | O | O | O | O | O |
| 4 | While doing this task I will enjoy playing the role of a scientist who is discovering relationships between things. | O | O | O | O | O | O | O |
| 5 | I feel under pressure to do this task well. | O | O | O | O | O | O | O |
| 6 | This task is a real challenge for me. | O | O | O | O | O | O | O |
| 7 | After having read the instruction, the task seems to be very interesting to me. | O | O | O | O | O | O | O |
| 8 | I am eager to see how I will perform in the task. | O | O | O | O | O | O | O |
| 9 | I'm afraid I will make a fool out of myself. | O | O | O | O | O | O | O |
| 10 | I'm really going to try as hard as I can on this task. | O | O | O | O | O | O | O |
| 11 | For tasks like this I don't need a reward, they are lots of fun anyhow. | O | O | O | O | O | O | O |
| 12 | It would be embarrassing to fail at this task. | O | O | O | O | O | O | O |
| 13 | I think everyone could do well on this task. | O | O | O | O | O | O | O |
| 14 | I think I won't do well at the task. | O | O | O | O | O | O | O |
| 15 | If I can do this task, I will feel proud of myself. | O | O | O | O | O | O | O |
| 16 | When I think about the task, I feel somewhat concerned. | O | O | O | O | O | O | O |
| 17 | I would work on this task even in my free time. | O | O | O | O | O | O | O |
| 18 | I feel petrified by the demands of this task. | O | O | O | O | O | O | O |

*Appendix 2*

Name: …….. Date: ……..

Age:…….

Gender: ……

Questionnaire 1

| | | disagree | | | | | | agree |
|---|---|---|---|---|---|---|---|---|
| 1 | I like riddles and puzzles. | O | O | O | O | O | O | O |
| 2 | I thought I was up to the difficulty of this task. | O | O | O | O | O | O | O |
| 3 | I did not managed to do this task. | O | O | O | O | O | O | O |
| 4 | While doing this task I enjoyed playing the role of a scientist who is discovering relationships between things. | O | O | O | O | O | O | O |
| 5 | I felt under pressure to do this task well. | O | O | O | O | O | O | O |
| 6 | This task was a real challenge for me. | O | O | O | O | O | O | O |
| 7 | The task seemed to be very interesting to me. | O | O | O | O | O | O | O |
| 8 | I was eager to see how I would perform in the task. | O | O | O | O | O | O | O |
| 9 | I was afraid I would make a fool out of myself. | O | O | O | O | O | O | O |
| 10 | I tried as hard as I can on this task. | O | O | O | O | O | O | O |
| 11 | For tasks like this I don't need a reward, they are lots of fun anyhow. | O | O | O | O | O | O | O |
| 12 | It would be embarrassing to fail at this task. | O | O | O | O | O | O | O |
| 13 | I thought everyone could do well on this task. | O | O | O | O | O | O | O |
| 14 | I thought I won't do well at the task. | O | O | O | O | O | O | O |
| 15 | I felt proud of myself after doing this task. | O | O | O | O | O | O | O |
| 16 | When I thought about the task, I felt somewhat concerned. | O | O | O | O | O | O | O |
| 17 | I would work on this task even in my free time. | O | O | O | O | O | O | O |
| 18 | I felt petrified by the demands of this task. | O | O | O | O | O | O | O |

*Appendix 3*

Logic gates test

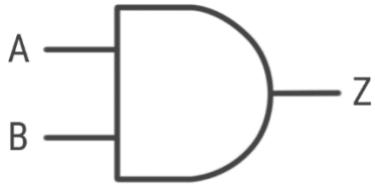
Name: …….

Date: ……..

Complete the following output tables.

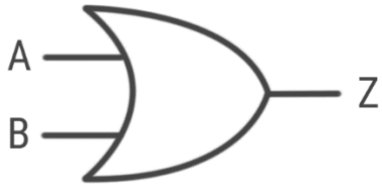
(i)

| Input AND Gate | | Output |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |



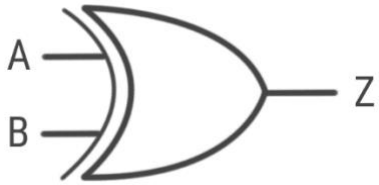

(ii)

| Input Or Gate | | Output |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |



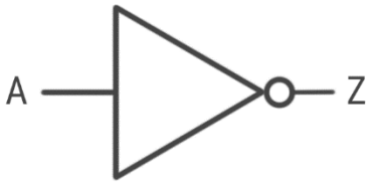

(iii)

| Input X-Or Gate | | Output |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |



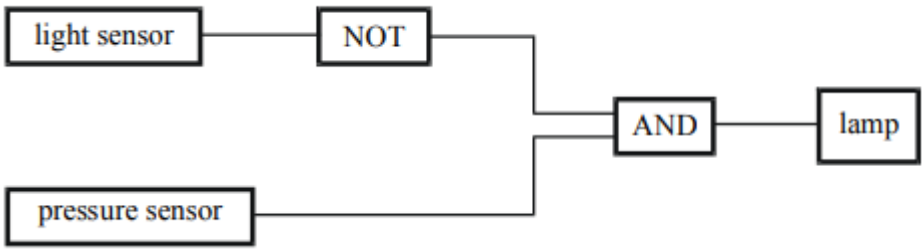

(iiii)

| Input Not Gate | Output |
|---|---|
| 0 | |
| 1 | |



A lamp outside a front door comes on automatically when it is dark and someone stands on the doormat outside the front door. A pressure sensor under the mat changes from OFF (0) to ON (1) when someone stands on the doormat. The light sensor is ON (1) when it is light and OFF (0) when it is dark.

The block diagram of the circuit is shown below.




What would happen when someone stood on the doormat when it was dark? Explain your answer.

What would happen:

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Explanation:

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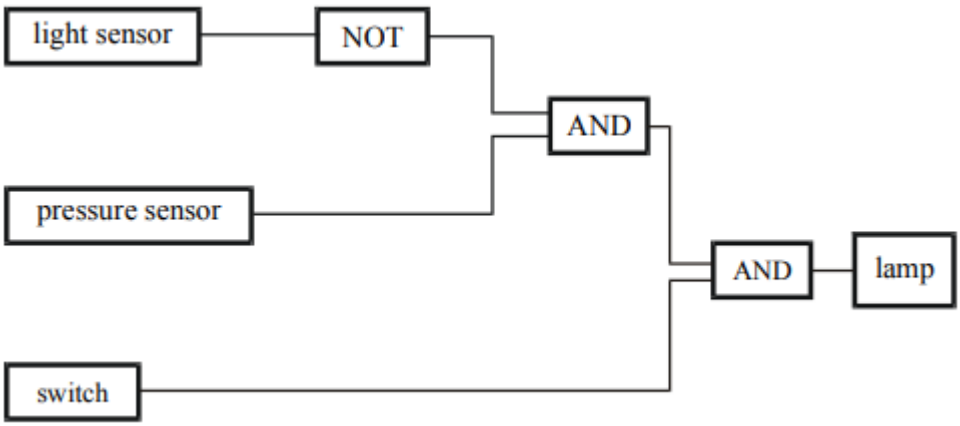
A switch is to be added to the circuit. The diagrams below show two ways of doing this.




Explain what the switch does in this circuit.

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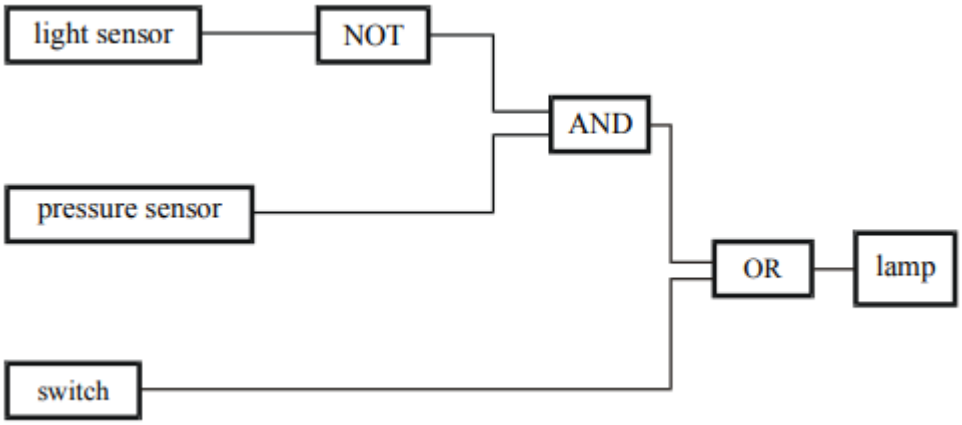


Explain what the switch does in this circuit.

.....

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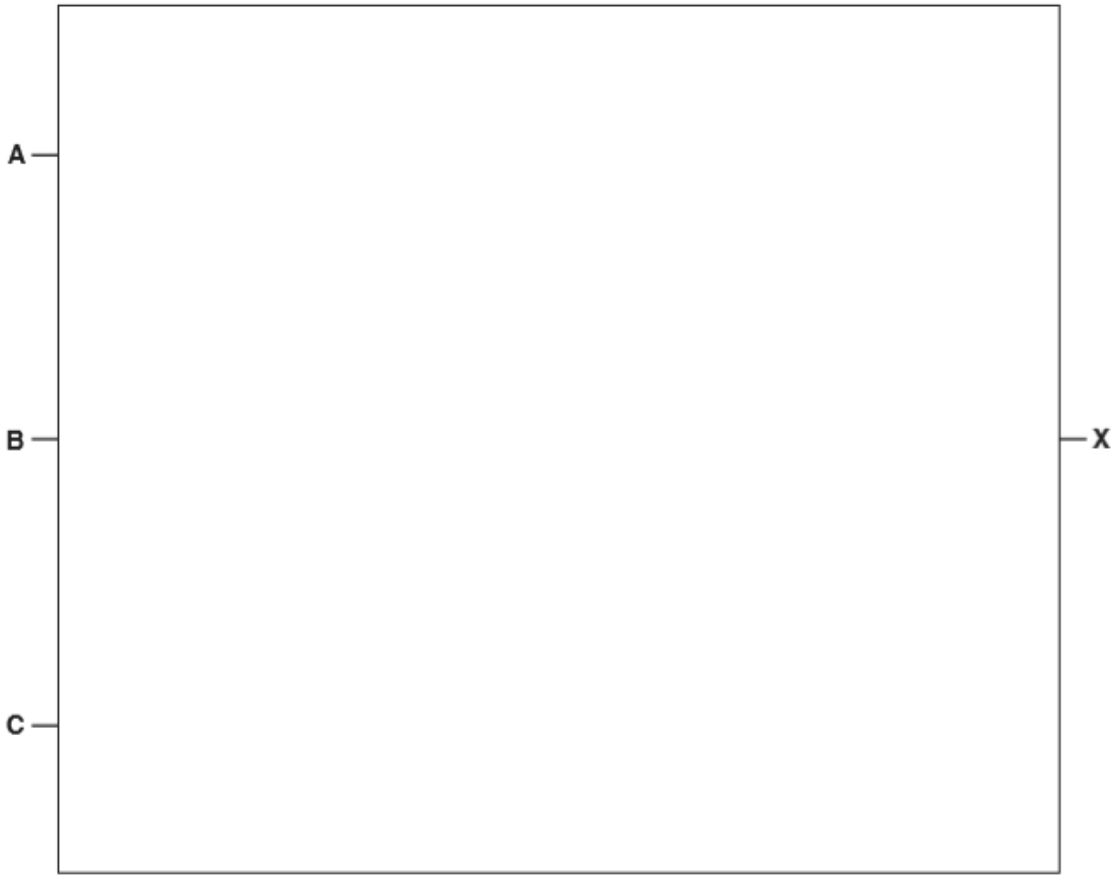
Draw a logic that represents the logic statement.

X = 1 if (A is NOT 1 AND B is 1) AND (A is NOT 1 AND C is NOT 1) OR (B is 1 AND C is 1)



A locker has been rented in the bank. Express the process of opening the locker in terms of digital operation.

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A bulb in a staircase has two switches, one switch being at the ground floor and the other one at the first floor. The bulb can be turned ON and also can be turned OFF by and one of the switches irrespective of the state of the other switch. The logic of switching of the bulb resembles.

O an AND gate
O an OR gate
O an XOR gate
O a NAND gate