ANALYSIS OF SERIOUS GAMES IN BIOLOGY

Thesis Presented

by

Ria Mittal

to

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In Partial Fulfillment of the Requirements for the Degree of Master of Science in Game Science and Design

Approval Committee: Dr. Derek Curry, Jennifer Gradecki, Dr. Celia Pearce

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ABSTRACT

The video game industry has been growing at an incredible rate. According to the American Psychological Association, over the past 10 years, scientists have conducted about 9 reviews of research on the effectiveness of educational computer and video games. They found that the research on games is highly diverse with a number of methodologically flawed studies. They agree that more research is to be done to design elements that work best at improving student learning. This study, researches learning effectiveness of the game design of one particular game in the field of educational biology - The control of the Cell Cycle published by NobelPrize.org. Participants of the age group 18-30, were tested upon highschool biology content, learning either through games or plain text. A qualitative and quantitative analysis were performed on their responses and discussed in the paper.

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TABLE OF CONTENTS

1. INTRODUCTION

Ever since the invention of papyrus, learning has been done on paper. This plain text on paper has been the culture for many years and thus is now the most traditional method of learning. Once the computer was invented, the version of paper based learning was mapped to a digital medium, which however still comes under the traditional text-based learning criterion, just in a digital form. Eventually, came the digital game-based learning, which is completely different from the paper or digital text-based methods. Even though the medium of digital game-based learning is fairly new, learning through play has been existent since before the invention of papyrus. For example, all animals have been learning through the medium of play. Even humans start learning when they play with things or with other human beings. Play is one of the main ways that children learn, says Family Lives (Family Lives, Retrieved 2018). They learn the basic skills of sharing, language, behavior or even throwing a ball. A young human start to build their personality depending on what they learn while they play.

A Serious Game is a game that is designed for a primary purpose other than pure entertainment. Depending on the industry and the exact type of application, the purpose of the games varies from training, learning and simulations to diagnostics and testing. During the last 10 years, an increasing number of Serious Games have been released which relate to a wide range of fields: healthcare, defense, education, communication, politics, etc. (Djaouti, D., Alvarez, J., & Jessel, J. (n.d.), 2009). Moreover, there have been even more games released since Djaouti et. al.

published these findings. Serious Games are entertaining and engaging and yet, satisfy another purpose.

Play supports players in exercising freedom that can complement formal learning by encouraging learners to explore various situations (Gloria, A.D et. al, 2016). This allows the players to be more engaged in the game for educational or pure entertainment, and enjoy it. The success of serious games for training has turned games into the best way of learning nowadays (Gamelearn, 2016). In addition to giving them a brief idea of the player's character under stress or his general attitude towards work, they are also effective in observing one's personality. These games challenge and support players to approach, explore, and overcome problems.

Since the inception of these games, an interesting area of research has been their efficacy, and the benefits of using these compared to a more orthodox method of learning. In the current work, a study of the effectiveness of Serious Games is presented, as compared to a more traditional approach of reading a page of text. In particular, this paper presents the learning effectiveness of a Serious Game produced by Nobelprize.org, The Control of a Cell Cycle, which presents the process of cell division in an interactive and educational way. This game was chosen on the basis of its simplicity and the straight-forward method in which it treats the subject matter. Although cell division is a common high school biology topic taught in most educational institutes, it is still complicated enough for those who did not pursue a formal education in biology to not have a comprehensive memory of the details. This limited selection of participants ensured the analysis of the learning rate to be unbiased.

Serious Games (SGs) are gaining an ever increasing interest for education and training in exploiting the latest simulation and visualization technologies. SGs are able to contextualize the player's experience in a challenging, realistic environment, supporting situated cognition (Gloria,A.D et al. 2014). The control of the cell cycle does exactly that. They put the player in a simulation where they pretend to be in control of the process of a cell cycle and they need to lead the game into a successful process by choosing the right option at the right time or phase of the process.

2. BACKGROUND

There are many definitions of a serious game. The most formal definition was introduced by a researcher, Clark C. Abt. In his book *Serious Games*, he presents games to improve education, both in and out of the classroom (Djaouti, D., Alvarez, J., & Jessel, J. (n.d.), 2009). A few years later, Sawyer and Rejeski (2002) defined serious games as connecting a serious purpose to knowledge and technology from the game industry. But irrespective of the several definitions of this innovation, it still works on bringing participants together from a wide range of paths and fields and uses their interest in video games to fulfill a purpose that goes beyond entertainment.

In order to analyze the effectiveness of a serious game, it is first important to know the difference between a serious game and an entertainment game. Richard (2012), in his paper, argues that there are often communication problems in serious games, as that communication reflects real life and thus cannot always be perfect. There could always be delays or misunderstandings (Bock

R.D, 2012). Whereas in entertainment games, the communication is always perfect as it is almost never completely based on real life. The table (Table 2.a)(K.B, 2018) below summarizes the differences between the two.

Table 2.a Difference between Serious Games and Entertainment Games

Game	Game-based learning (Serious Games)
Games are for fun, and may or may not have defined rules and objectives.	Games have defined learning objectives.
Winning and losing, if any, is a part of the game.	Losing may or may not be possible because the point is to motivate people to take some action and learn as an end result.
Game play comes first, rewards are secondary.	Sometimes just playing the game is intrinsically rewarding.
Story and scenes are part of the game.	Content is usually morphed to fit the story and scenes of the game.

Serious games can help the player learn a lot of different skills, user behavior, or even teach them knowledge about a particular subject. Digital games help students with their problem solving skills and other deep level thinking instead of just memorizing the subject. The first step towards understanding how computer games can transform learning and education is changing the widely shared perspective that games are "mere entertainment" (S Gayla. K, 2011). The main benefit of educational games is that the students can work on various skills and courses at once without feeling the burden to learn because it's more fun than the stress of being forced to learn. Serious games are an interactive method of play that teach students goals, rules, adaptation, problem solving interaction, all represented as a story (Bock R.D, 2012).

But there are also some disadvantages of learning through games or education through games. It is very difficult to determine how long a student would take to learn from these games, to determine how long they will take to complete the sub goals and ultimately the game itself. This could pose a problem to the teachers to set up the timeline of the syllabus. With a set deadline, the student may also get discouraged for not being able to complete the game before the deadline. This will risk some of the kids falling behind. Another major problem is that the game culture and play could be disadvantageous if it is not designed correctly.

Dr. K Mitgutsch, a researcher at MIT University and the founder of Playful Solutions, has been studying the design of purposeful games. He proposes four advantages and disadvantages of educational games. He states the advantages as:

1. Challenge: These games increase the difficulty level as per the player skill. This allows them to learn from their mistakes.
2. Explore: Players can test their own ability and explore the virtual consequences of their own action.
3. Explore roles and identities: A new perspective opens with every challenge and stimulates the learning processes.
4. Application and feedback: Allows the player to put what they have learnt in practice and find out if their abilities are sufficient enough to meet the requirements.

The players' own progress in the game gives them the reassurance of having achieved and learnt something new (Mitgutsch.D.K, 2014). The four disadvantages according to Dr. K. Mitgutsch are:

1. Simplification: Games reduce the complex systems to their core aspects and represent the real world. But the world we live in is far more complex for any game to capture the essence of it.
2. Lack of context: Games are not designed to have any impact on the player once the game has been switched off.
3. They are illusions: challenges in video games are mostly fictional and have no relevance in everyday life.
4. Relation: Kids are not able to relate what they have learnt to the real life.

The learners require constructive support if they are to take anything relevant to their own learning process with them from the productive game settings (Mitgutsch.D.K, 2014).

It is a fact that playing is an important aspect of human development which thus leaves a big impact on the players. Games support the development of certain skills: strategic skills, analytical skills and learning capabilities (Granic. I, 2014). So why not use this quality for a purpose bigger than entertainment?

3. METHODOLOGY

Serious games offer the ability to extend learning outside of the classroom and can be an attractive option for everything from teaching flashcards to model-based teaching. Medical schools around the country are increasingly utilizing and creating educational games for learners (Knops.B, 2013). The repertoire of computer strategies for medical education is becoming wider with the introduction of e-learning, game-based learning, gamification, and mobile learning (G Iouri et. al, 2018).

In order to analyze the effectiveness of serious games in biology, this project was initiated by picking a pre-existing, high school level, biology based game. As mentioned in the previous section, the chosen game is The Control of the Cell Cycle produced by Nobel Media. This game is based on the 2001 Nobel Prize winning concept in Physiology or Medicine, which was awarded for discoveries concerning the control of the cell cycle. It is a really simple game to play and understand, even for a person without a medical or biology background.

In this study, I am analyzing whether learning biology through games is equally or more effective than learning the subject using traditional methods of learning, that is, through reading plain text. For this, two participant groups were randomly created—the control group would read an article, and the experimental group would play the game with the same exact information as the article provides. The game provides this information before the player plays the game as this information is required to play the game. This game is very descriptive and has a lot of text. So to make the article unbiased, the text was cloned from the game. This ensures that the same exact information is provided to the control group just as it is to the experimental group. The computer software, Qualtrics, sorts the two groups at random in order to avoid any kind of bias.

In order to test the learning curve of the player, it is important to first know the baseline of how much they already know about the topic. In order to do this, there were two tests that were prepared. One test, the pre-task test, was answered by the players before they attempted to play the game or read the article, and the other, the post-task test, was answered after they completed their tasks. Both the control group and the experimental group were given the same pre and post questions. Although this research is primarily focused on the test scores that the participants provide, it also requires the player to complete a short survey asking how they felt about the game or article.

3.1 The Game

The cell cycle is the series of events that take place as the cells grow and divide. In mammals, this process has four phases—Synthesis, G1, G2 and Mitosis Phase. The Control of the Cell Cycle game teaches us about all the mechanisms that take place in our body during each of these phases. The game is easiest to finish if one is familiar with these different phases of the cell cycle. If not, then one would have to pay extra attention to all the texts and images of the game. This is where the specific participants, who do not have a biology background, fit in. This specific group of participants will ensure that they are learning new information through the game or the article. Participants who have an academic biology or medical background may have recent memory of the subject and thus will be recollecting the information rather than learning it. Since this study focuses on the learning rate of the two methods, participants of the latter type were not suitable.

In order to divide without any errors, all cells follow the cell cycle. This division happens throughout the day but peaks around 2:00 am (The Science of Beauty Sleep, 2017). This means that cells rejuvenate the most when we are asleep. And that is exactly how the game starts (see Fig. 3.1.a). As soon as you enter the game, you see a little boy sleeping in his bed and an information box below him. This box gives interesting facts and the information needed to play the game.

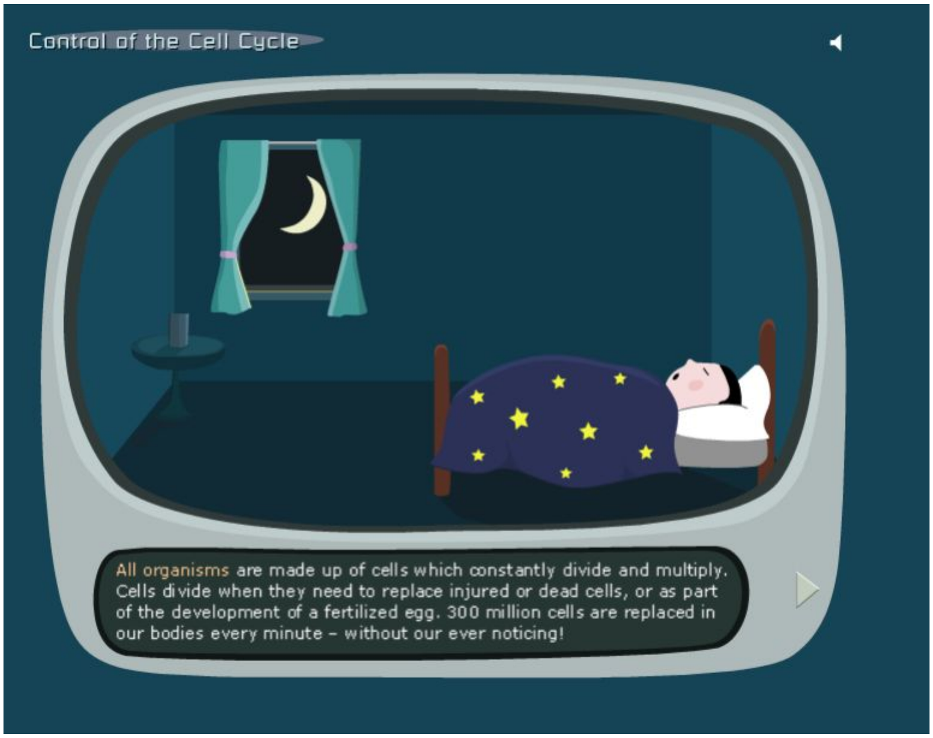

Fig. 3.1.a. The general look of the game (first scene)

As the game progresses, the players start to receive more and more information about the cell cycle (as shown in Fig. 3.1.b). As the information reaches its end, the goal of the game starts to reveal itself. The goal is simple and straightforward. You (the player) are the molecules, in a boy's body, and you control the cell cycle, namely CDK (Cyclin-dependent kinases) and Cyclin. CDK and Cyclin are the two molecules responsible for an error-free cell cycle. Your mission is to do the same, conduct an error-free cell cycle. You are in control of this process and you can do this by choosing the right step for the right phase.

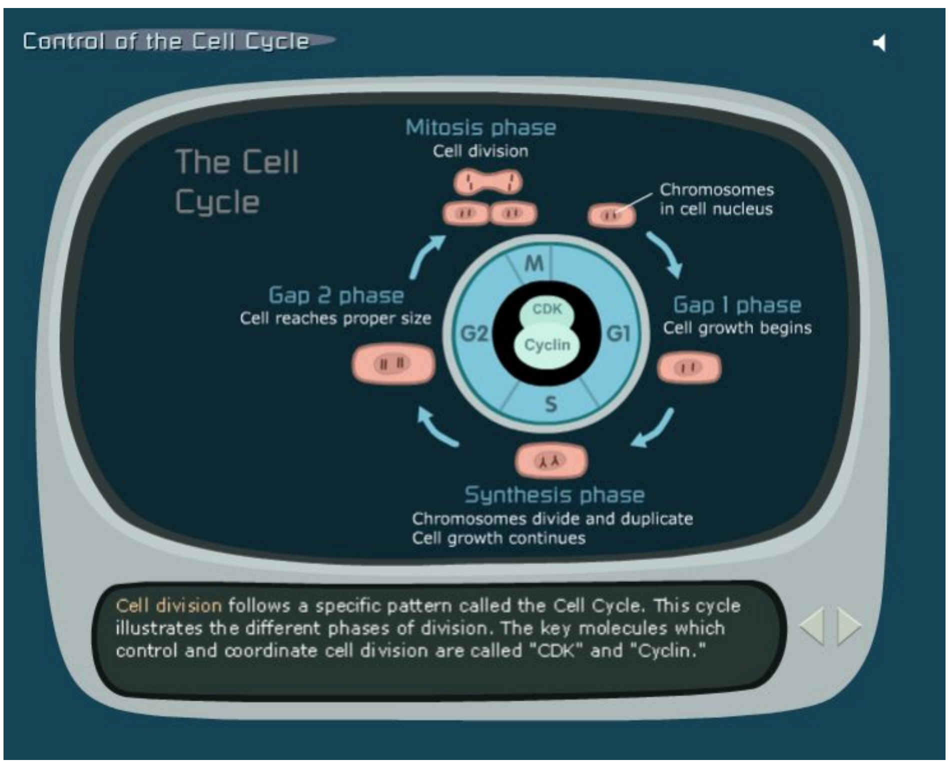

Fig. 3.1.b Game information on the cell cycle

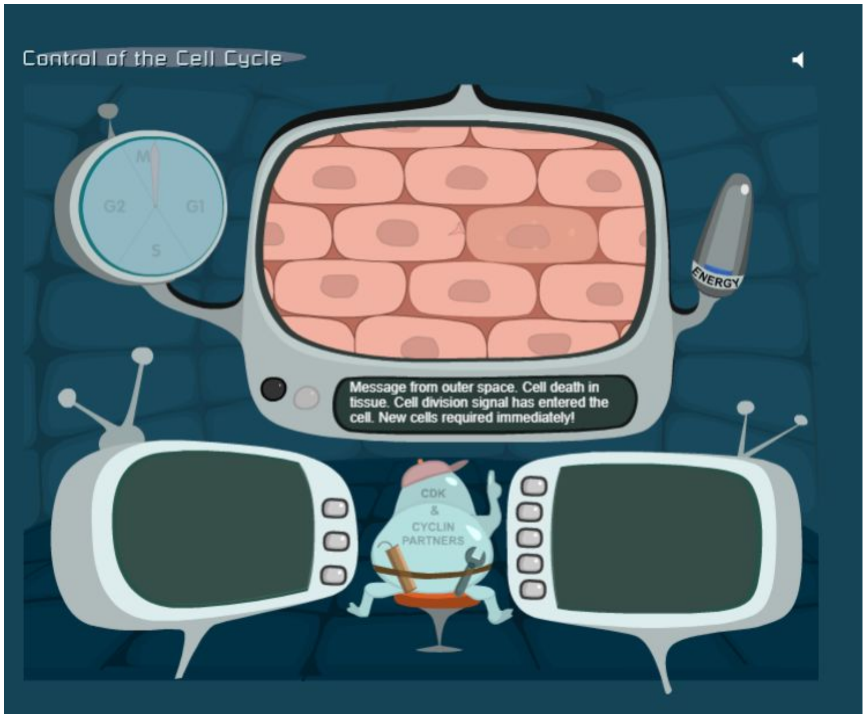

Fig. 3.1.c Image of the Player character and his control unit

As it can be seen in the figure above (Fig. 3.1.c), the player is the blue blob which is namely CDK and Cyclin. The monitor in the center shows what is happening to the cell at every phase of the cell cycle. The monitor on the right of the screen is where the choices pop up and the player has to pick the right step for the particular phase the cell is in. As long as the player picks the right option, the game moves forward. The monitor on the left of the screen is the monitor on which the checkpoints of every phase are mentioned. This information is not necessarily present in the text which is provided to the player before they start playing the game. These checkpoints keep the player active because it is new information that they learn in the middle of the game. At this point, they click on every checkpoint and see on the screen what exactly happens to the cell. This is one of the learning techniques that the game uses to teach it's players.

The game keeps moving forward when the player chooses the correct option. If they pick a wrong option two times, then their cell dies and they have to restart the whole process again with a different cell. If they do not get the process right in the first three tries, then they have lost the game and have to start it all over again.

3.2 The Article

The article is the exact clone of the text which is mentioned in the game. The game features no dialogue, which means that all the data and information that are provided by the game is in text and thus can easily be written in the form of a short article. Even the checkpoints during the game can be rephrased in form of a text. In addition, there is a lot of information that is provided when the player finishes the game. This new information was also added to the article that was provided to the control group. This ensures that both the control group and the experimental group have the same data in the exact same format and the language used. This makes sure that there is no space for any information based bias that could alter the results.

3.3 The Survey/Test

The entire study and the responses were collected online. The survey was planned and executed in the manner shown below.

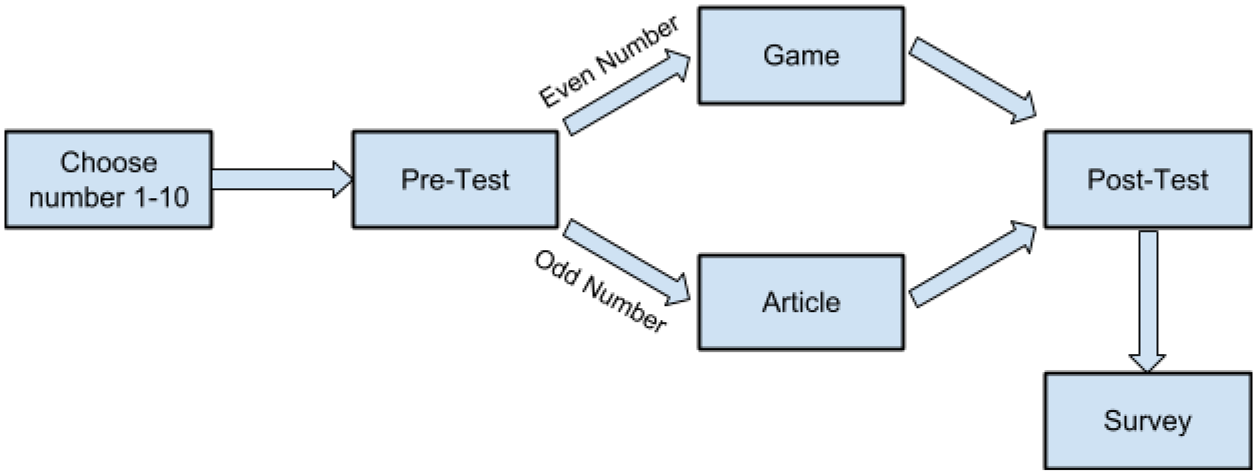

Fig. 3.3 a Survey Flow

As it can be seen from the image above (Fig. 3.3 a), the survey starts with a number choosing metric. This is the mechanism that was introduced in order to randomize their assignment to the game or the article. If the player chose an even number, they were assigned to the experiment group with the game condition. And if the player chose an odd number, they were assigned to the control group with the article condition. After they selected a number, they went through a pre-task test which provided the baseline of the amount of previous knowledge they have about the topic. The pre-task test consisted of seven simple objective questions with a time limit of 4 minutes. As this study is completely online based, the pre-task and the post-task tests were timed to avoid having the participants browse the internet for answers.

After they completed the pre-task test, they were asked to attempt the task they were chosen to do which was assigned depending on the number they chose at the beginning of the survey. There was no time limit for this task. They took as much time as they needed to. Ideally, the game and the article, both should have taken only 20 minutes. The participants were requested to finish the game and read the article completely. Once the participants had completed their task, they moved on with their survey where they would find the post-task test. The post-task test consisted of 10 questions which contained the same questions but worded differently. This test was also timed for 4 minutes. Both the tests are timed so that the participants do not get enough time to browse the answers on the internet. They also have an option of “I don’t know” so that the player have an option of not guessing the answer and rather, truthfully admitting that they do not know the answer. In addition, the players were requested not to guess and to answer to the best of their knowledge. As there was no way of keeping a track of the way the participants would answer, the “I don’t know” option was to provide a certain comfort level with which they can admit that they do not know the answer to the question. A guessed answer would give an unreliable response which can alter the analysis. The survey has no access to visit the previous pages and thus the article control group, were not able to refer the article again. This made sure that they did not read all the test questions and go back to the previous page to find the answers in the article.

Once they completed the post-task test, a short de-briefing explained them about the study and what the research was aiming at. After the de-briefing, they got a short three question survey asking them if they liked the task and if they would have preferred learning the information through a game or an article respectively.

As mentioned in the methodology section, a computer software named Qualtrics was used to spread the survey around. A combination of Qualtrics and Microsoft Excel was used to analyze the response data to reach an acceptable conclusion to the study. Qualtrics is a subscription software for collecting and analyzing data. This survey tool has a wide range of tools with robust analytical reporting (Steber C, 2016). On the other hand, Microsoft Excel is used worldwide for data analysis as it is both, convenient and cost effective (Rose S, 2015). Both these tools were used to analyze data and create charts and tables to visualize the data.

3.4 The Procedure

Participants

This study aimed to collect at least 60 participants: 30 for the article control group and 30 for the game experimental group. In order to recruit participants, the study was posted on several social media platforms like Facebook and Reddit. It was also disseminated using Whatsapp and requesting people to forward it to their friends and family. The recruitment materials specified that the participants must be between the ages of 18 and 30 with a non-biology background. This means that they should not have studied biology or any such related field after high school. This was meant to ensure that the player had less information on the topic to align more with comments about this topic that arose earlier in the paper.

A message specifying the participant requirements and the link to the study was provided. A total of 159 participants were collected as a combination of both the control group and the experimental group. Out of this, about 62 participants were filtered out due to incomplete data.

Out of the 62, 15 from the game experiment group and 15 from the article control group were filtered out based on the amount of time they took to complete study. From calculating the average time participants took to complete the article, an acceptable time range of three to seven minutes was used as a metric to select the 15 responses. Similarly, the acceptable time calculated for the game experimental group to finish their task was 10 to 30 minutes and then 15 responses were chosen that belonged to this time range. Participants who took significantly more or less time were filtered out as they either did not complete the study in absolute honesty or they did not complete it in one sitting. A better analysis can be done on the responses who completed the study properly.

Data Collection and Analysis

As mentioned, the study was done using a Northeastern subscribed software called Qualtrics. Once all the data was collected and sorted, the pre-task and post-task test responses were evaluated in order to check the score of each selected participant for both the control group and the experimental group. The total scores of participants in the tests and the number of times they chose “I don’t know” was recorded. This data was then entered into the excel sheet and this quantitative data was analyzed. An average score of the pre-task and post-task test scores were calculated. The two average scores were used to analyze the learning rate of the control group and the experimental group. In addition to this, reports from Qualtrics regarding the response on the survey was collected and discussed on.

This study uses a combination of qualitative and quantitative analysis. Quantitative analysis is done with the test score of each participant and qualitative analysis is performed on the survey answers from the participants.

4. RESULTS

The pre-task and post-task test results were noted and the average of their score was calculated and based on that the percentage of change was calculated using the formula below:

$$Percentage\ of\ change\ =\ [Difference\ in\ score]\ /\ (pretask\ test\ score)\ *\ 100$$

Please note that the traditional learning method is termed as article as the text provided in the study to the traditional method control group, was an article.

The calculations are noted as shown in the table below (Table 4.a):

Table 4.a Average scores and the percentage of change of participants in each group

	Pre-task Average Score out of 7	Post-task Average Score out of 10	Percentage improvement over pre-task score (%)
Game	2.766666667	7.433333333	88.07228913
Article	2.7	6.733333333	74.56790123

As it can be seen from the numbers above (Table 4.a), that there is a significant increase in both the media of learning. However, the game medium had more than 10% effect on the learning rate as compared to the medium of learning through traditional methods (article). The pie chart below

(Fig. 4.a) shows the percentage improvement in the scores, which can also be interpreted as the learning rate for the type of media:

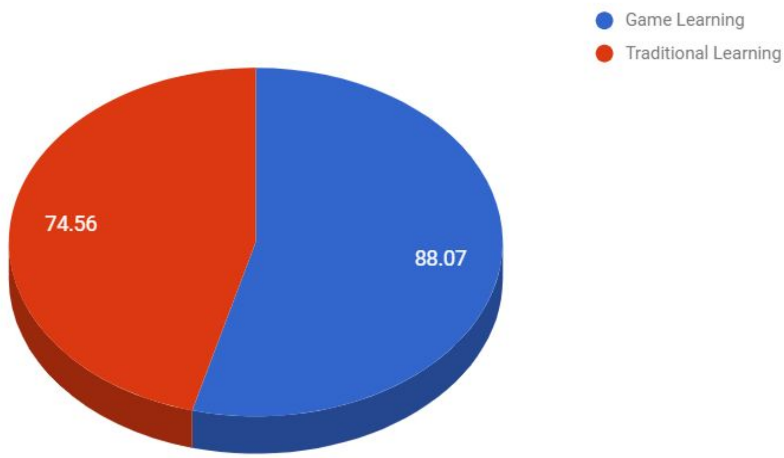

Fig. 4.a Pie chart showing the learning rate of both control groups

Graphs were plotted for the game pre and post-task and for the article pre and post-task test score for every participant. The graph is as shown below:

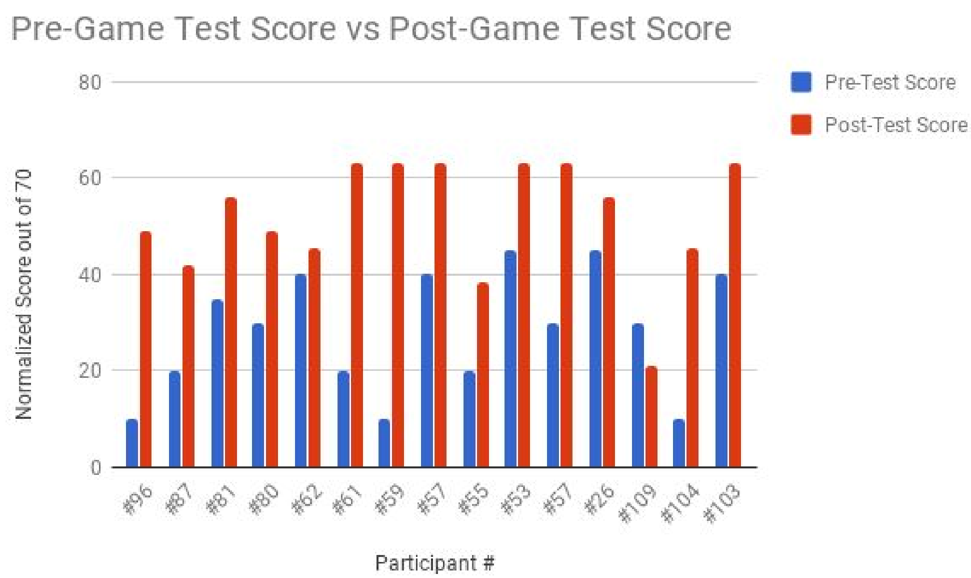

Fig. 4.b Graph showing the pre and post task scores of each participant in the Experiment group

The scores help in identifying the increase or decrease in the learning rate of both the media with their pre-task test score as the baseline. As you can see from the graph above (Fig. 4. b), the participant scores have increased significantly in the post-task test, indicating that participants are learning from the game. Therefore, games as a learning medium are effective. Out of these 15 participants, 4 participants have a clear-cut improvement in post-task test score compared to the other participants, which suggests a strong learning rate from this game. Another interesting observation is that, with the exception of one participant, almost all the participants scored higher in their post-task test compared to their scores in the pre-task test. A notable outlier is participant #109 who scored less in their post-task test which suggests that they did not learn anything at all, or possibly did not take the test/game seriously .

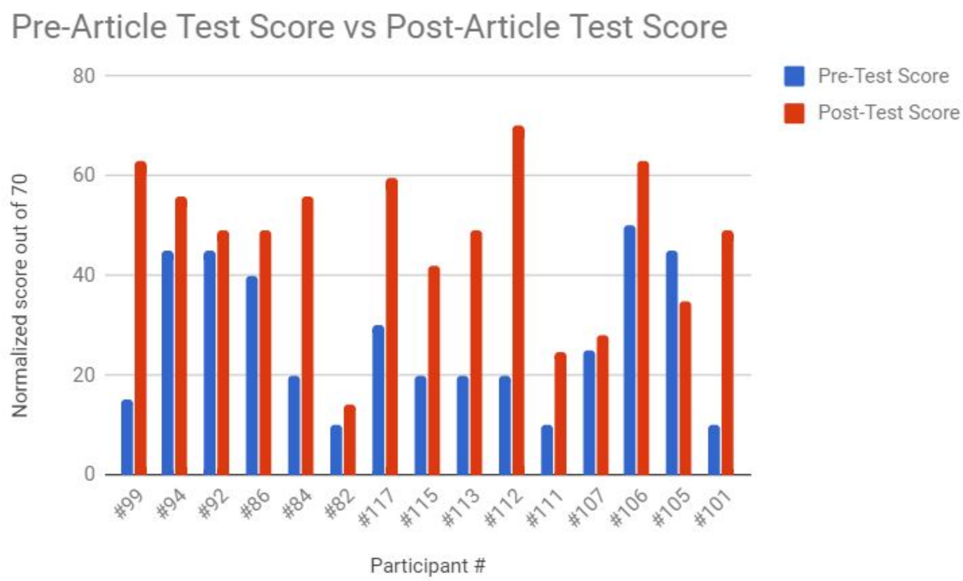

Fig. 4.c Graph showing the pre and post task scores of each participant in the Control group

Learning begins slowly, increases exponentially, and then slows to near zero level when mastery is attained. A graphical representation of this is called the learning curve (Rouse M, 2016). In this study, there is a shallow learning curve for the group who read the article, compared to the group who played the game. This factors that the learning rate is slow. We know that this method already works as it is still used in most schools and training facilities. It is not a surprise to see that everyone has learnt something from the piece of text that was provided to them. The graph (Fig. 4.c) shows that in this group, about six people have had an extreme increase in their post-task test score. On the other hand, the scores of participant #82 and #92 in the post-task test is not much different from their pre-task test score. Given that their pre-task test score is low and there is not much improvement in the post-task test score, it can be inferred that their learning rate is close to zero which infers almost no learning at all. This may indicate that the participant did not read the article properly and thus, is an outlier.

The graphs below show the learning rate of every participant in the experimental group.

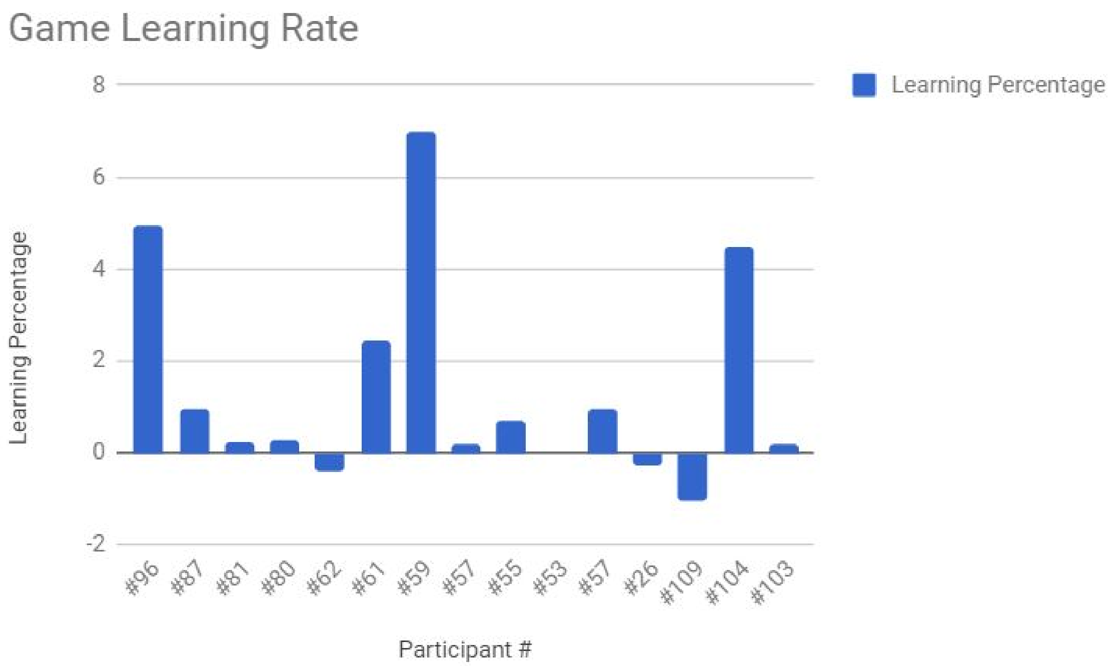

Fig. 4.d Graph showing the learning rate of each participant in the Experiment group

This is a very interesting graph (Fig. 4.d). As you can see in this graph one participant has had a really high learning rate. This means that this particular person learned a lot from the game. And there were three other people who had an observable increase in their learning rate. Unexpectedly, the graph shows that there are some participants who have a dip in their learning rate. As per the graph there are 4 people who have had a dip, which means that they are close to not having learnt anything at all. The graph for participant #53 is not missing, t is just such a minute (negative) change that it could not be recorded with the graph on such a high scale.

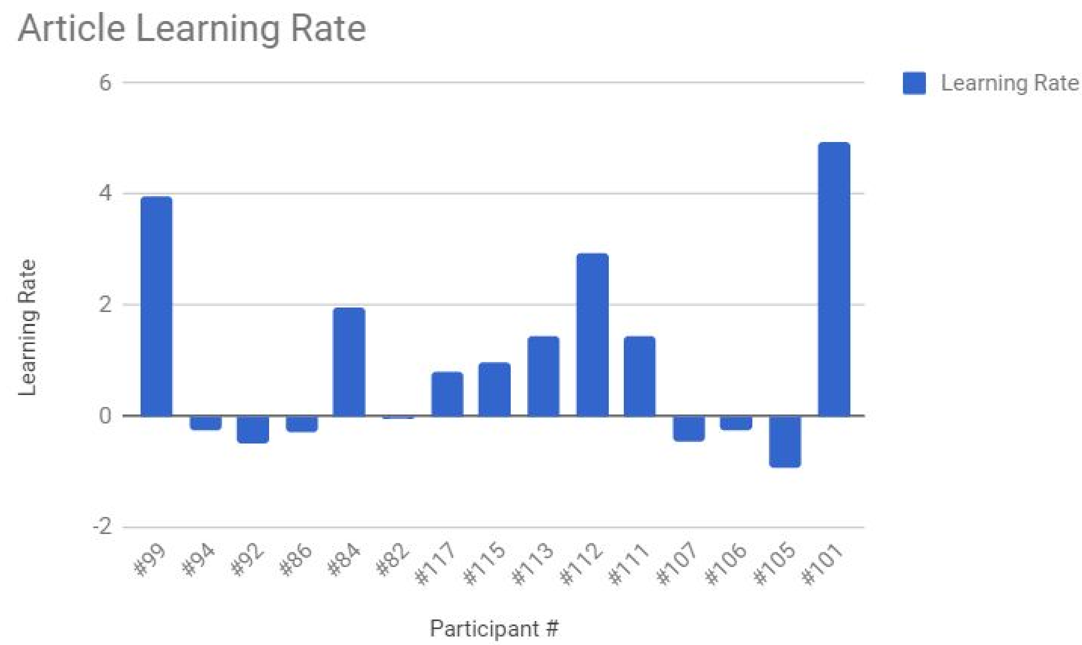

Fig. 4.e Graph showing the learning rate of each participant in the Control group

This graph (Fig. 4.e), is extremely different from the Game Learning rate graph (Fig. 4.d). As you can see there are about four people who have a significantly higher learning rate compared to the other participants in the group. But their rate is not as high as the graph of the Game Learning rate. Another observation is that there are seven people below the learning line. That is double the number of dips in the game graph. So that means there are twice as many participants who appear not to have learned from the game.

Below is the most interesting graph (Fig. 4.f) of this study. It indicates that games are slightly more better learning medium than traditional text articles.

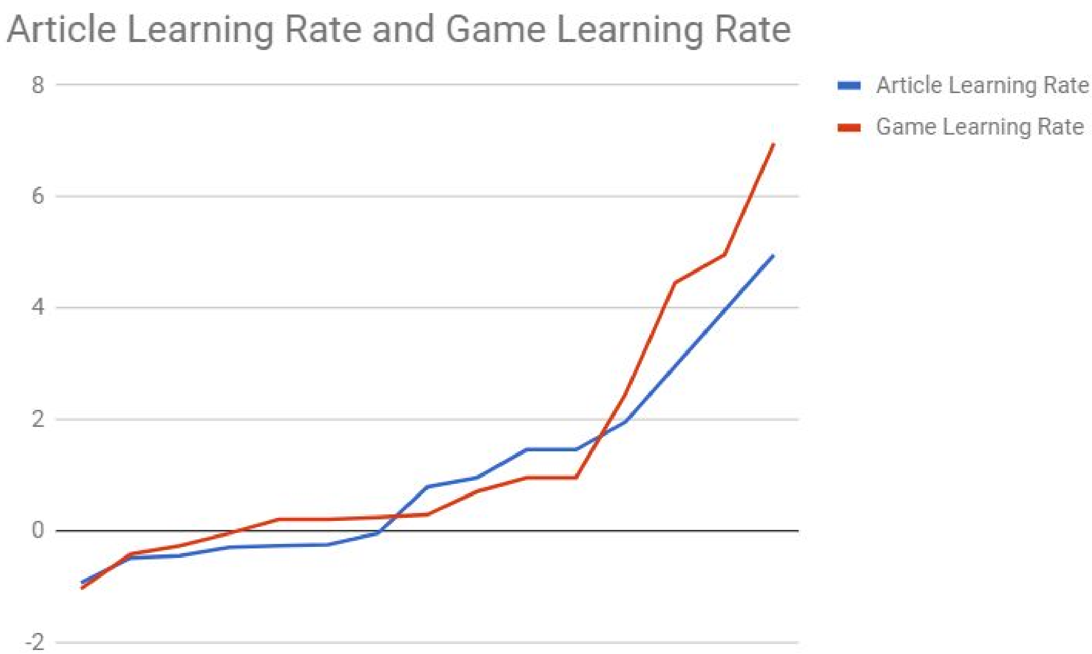

Fig. 4.f Graph showing the learning curves of the control group and the experiment group

The graph (Fig. 4.f) above shows the learning curve of the two learning mediums. In order to get this curve, the learning rate of every participant of both the groups were calculated and the graph was plotted. This interesting graph gives us a lot of information. The curve of the game learning rate is most of the time above the article learning rate curve. So, according to this graph, people learn more through games. You can also notice that the highest learning rate again belongs to the game control group with a rate of 7% increase. But, the lowest score also belongs to the same control group with a learning rate of -1.04%.

5. DISCUSSION

The hypothesis was that the players would essentially learn more by playing games rather than than learning by the conventional method. The rapid growth of multimedia technologies over the last 20 years means that today's children and young adults were born in a computerized world and are used to handling all kinds of software products and games (Girard C, 2012). From the analysis above, it can be inferred that learning through games is at least on par with learning through traditional linear methods, if not better.

There were also some quantitative charts that were generated from the survey questions that were asked to be filled after the study terminated.

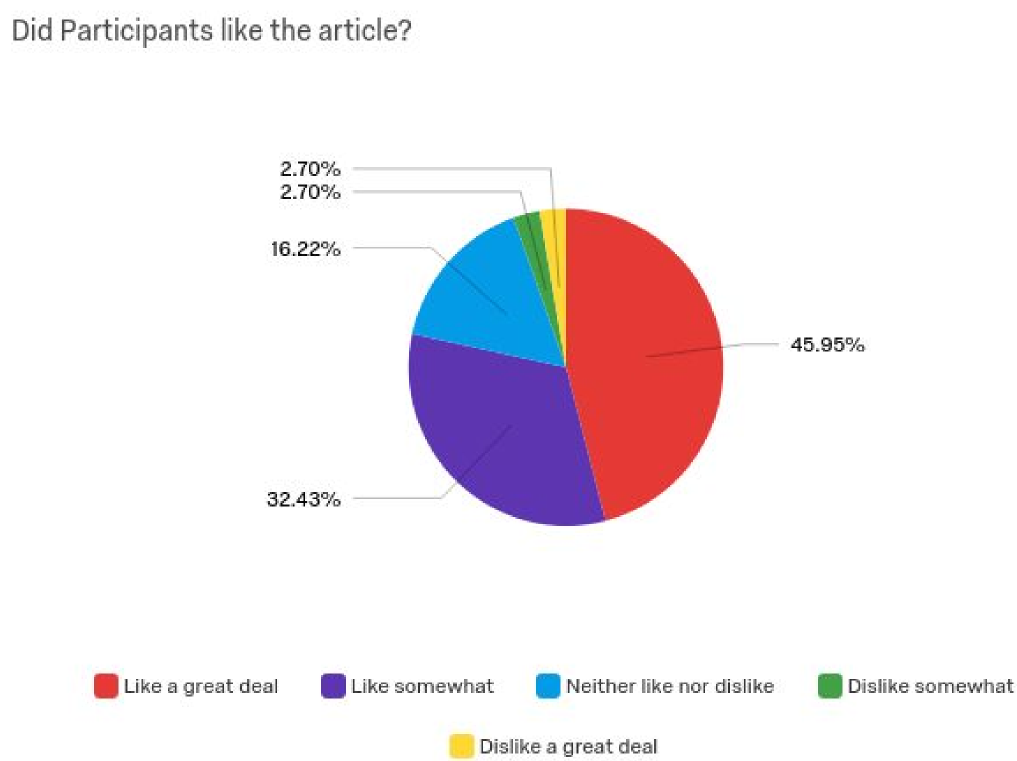

Fig. 5.a Did the participants like the article.

The graph (Fig. 5.a) above, shows the distribution of participant responses to the question of whether or not they liked the article. It can be observed that about 45.95%, which is almost half of the total number of participants, liked the article a great deal, whereas 32.43% of the total participants liked the article. This constitutes more than half the control group who like the article. The graph (Fig. 5.b) produced when asked if the participants like the game, is very different from the graph (Fig. 5.a) generated above.

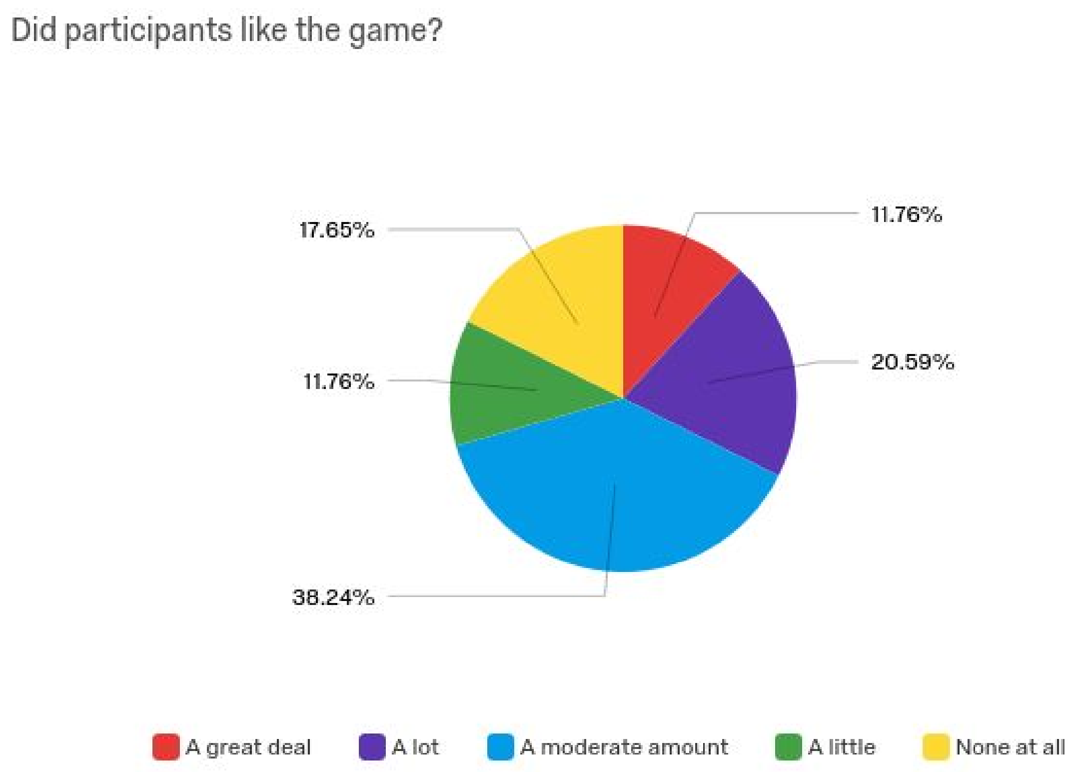

Fig. 5.b Did the participants like the game.

In the graph (Fig. 5.b), it was observed that very less participants liked the game. Maximum number of participants chose the option of “a moderate amount”. From the graphs above (Fig. 5.a and Fig. 5.b) we can infer that people liked reading the article more than they liked playing the game. Due to this observation, the study sought to understand why the participants felt the article was enjoyable whereas the game was not. A sub-hypothesis of this study was that the participants would find the game more fun than the article. But I was not able to analyze this without performing further tests and surveys.

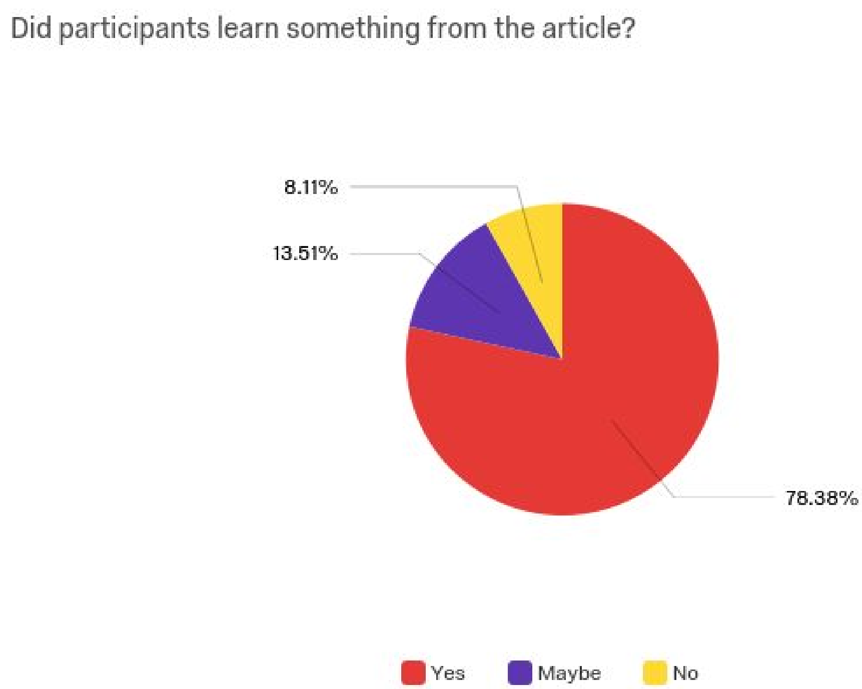

Fig. 5.c Do the participants think or believe they learned something from the article.

The graph (Fig. 5.c) above shows the percentage of participants who liked the article and who did not. According to the graph, 78.38% of the participants liked the article.

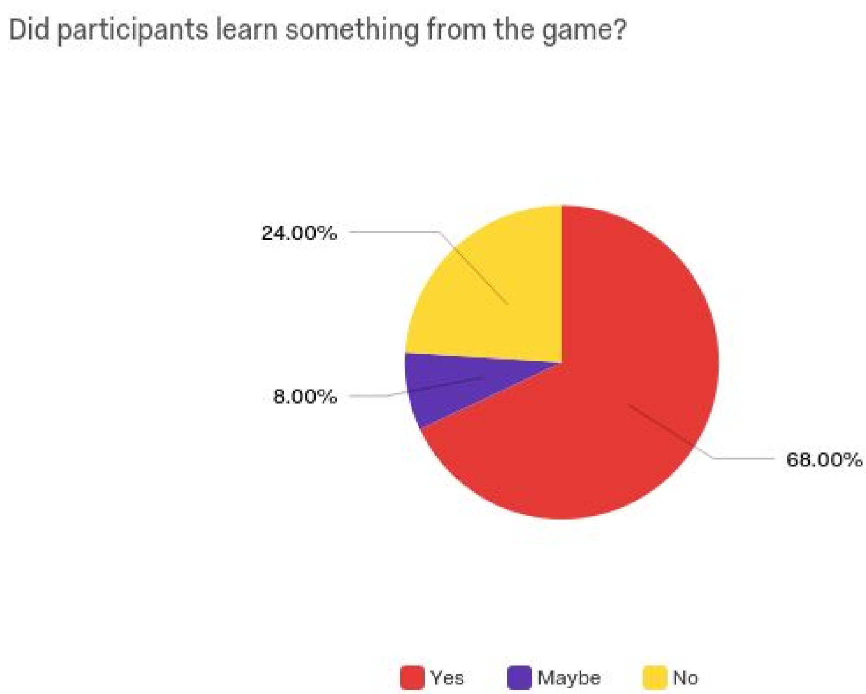

Fig. 5.d Do the participants think or believe they learned something from the game.

The graph (Fig. 5.d) above, shows us the percentage of participants who believe they learnt something from the game. The graph shows that 68% of the participant population feel they learnt something from the game. Comparing the two graphs (Fig. 5.c and Fig. 5.d), it can be seen that almost the same amount of the population feel like they have learnt something from their tasks. There is only a 10% difference between the two graph analysis. However, when we compare graphs Fig. 5.b and graph Fig. 5.d, it can be seen that the largest percentage of participants did not like the game, whereas, a large percentage of the participants feel like they have learnt something from the game. This shows that even though the population did not really like the game, they still felt like they have learnt something from it. Only 11% of the population liked the game but 68% felt like they have learnt from it.

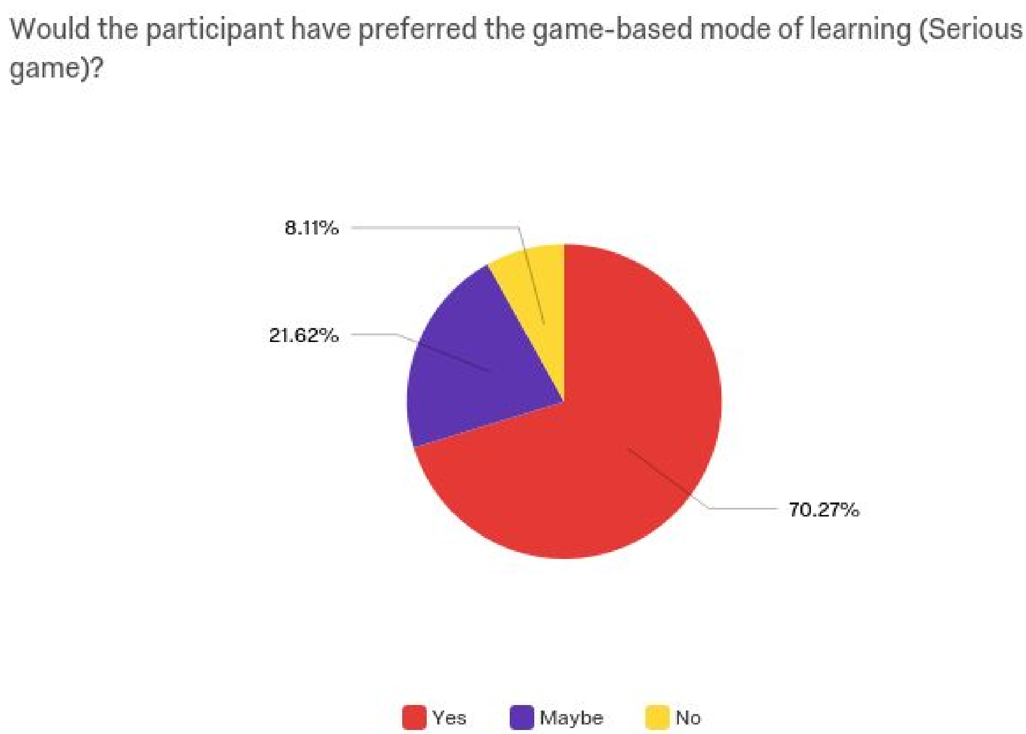

Fig. 5.e Would the participants have preferred a game-based approach of learning?

Observing the graph (Fig. 5.e) above, the majority of participants would have preferred a game-based approach of learning. Less the 10% of the population would not have preferred the game medium path for learning.

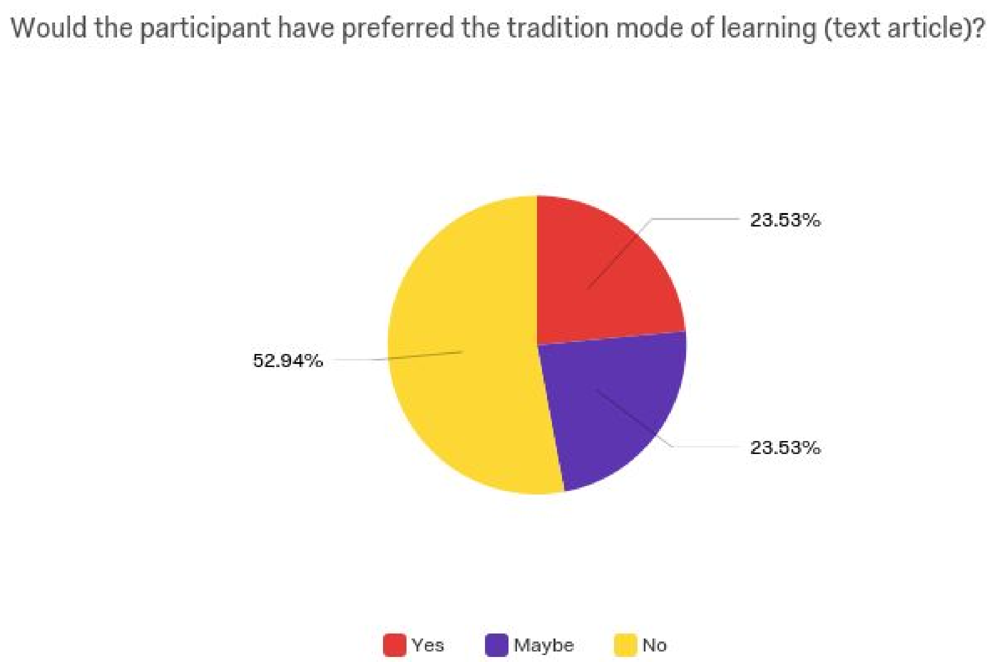

Fig. 5.f Would the participants have preferred learning through the written article?

The graph (Fig. 5.f) above, shows us the percentage of people who would have preferred the article mode of learning. More than half the population did not prefer the article mode of learning. However, there was almost a quarter, 23.53%, of the participant population who would have preferred the article medium of learning. he remaining quarter of the population was skeptical about if they would have preferred the article medium of learning. Comparing the graphs Fig. 5.e and Fig. 5.f, it was analyzed that when combined, the majority of participants would have preferred the game-based approach of learning and about less than 25% of the population was skeptical in choosing the other medium of learning.

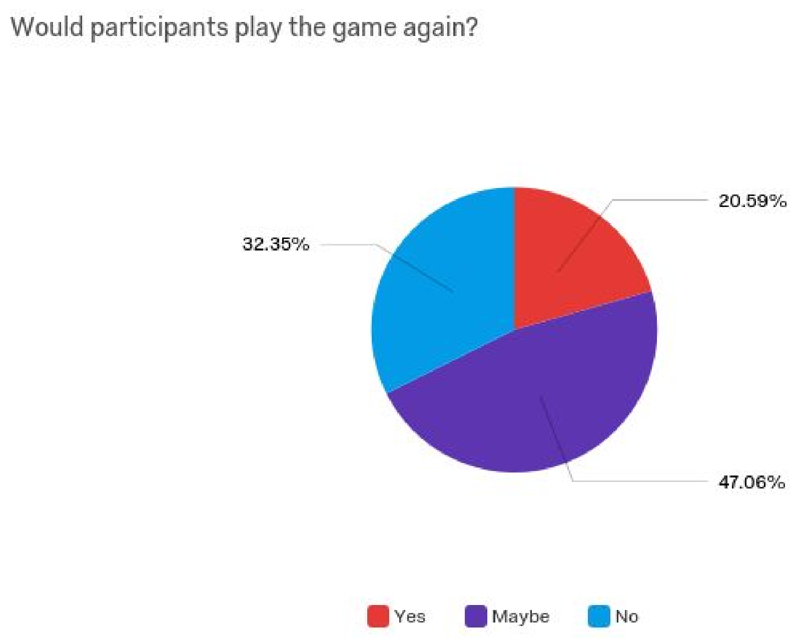

Fig. 5.g Would participants play the game again?

As an additional analysis, the study collected responses to know what percentage of the population would play the game again. As per the graph (Fig. 5.g) above, it can be seen that most of the population were unsure of whether or not they would play the game again. But, the next highest percentage of the participant population, 32.35%, mentioned that they would rather not play the game again. Comparing this graph with the previous graph (Fig. 5.d) mentioned, it can be observed that even though the majority of the participants felt like they learnt something from the game, less than 75% of the same population would not like to play the game again.

Learning through games has its ups and downs. As you can see from the study above, the group assigned to the condition of reading an article took an average of 5 minutes to complete the whole study. Whereas the game control group took an average amount of 15 minutes to complete the study. This means that people took three times as long to learn a little more than learning through the traditional method. So that means that this method might be more engaging, more fun and there is a possibility of a lot more learning. However, beyond engagement, games may also be used for learning and developing personality (Foster, A, 2008).

Although the data collected from the analyzed responses are partially conclusive, there are a few limitations without which the study could have been more precise. This study was a short-termed study and thus cannot completely conclude whether games are a better medium of learning than the traditional method. This study took place online and the participants could not be observed to keep a track of how they were completing their tasks. Another main limitation is the number of participants. In order to perform a more accurate analysis, a larger participation pool would have supported the argument in a stronger way. However, this study is adequate for a short-term learning rate analysis.

6. CONCLUSION

This study shows that participants who are unfamiliar with microbiology learn better by playing a game than reading an article about the cycle of cell division. Games are more than just entertainment. They can be used for a much bigger purpose at a much wider scale: education. Games in education is an upcoming technology which will keep players of all ages engaged and wanting to learn more and more.

With respect to serious games in biology, this could change the face of learning biology or any other higher degree like a medical degree or a pharmacy degree. Showing a graphic or an interaction of what happens in our body or the chemistry behind certain things could catch and keep their attention. This way the information keeps entering the brain and eventually becomes a memory. This study shows that participants from the experiment group who played the game retained more information about cell division in the short term compared to the control group who read the article.

Another conclusion inferred from this study is that people spent more time in playing the game compared to the time the experiment control group participants took to complete their task. Also, people may like the game and learn from it but not necessarily want to play the game again. This may limit the amount of practice one needs to make a temporary memory permanent. Also, even though participants feel like they have learnt a lot from the article, they would prefer a game-base mode of learning. Overall, learning through a game outperforms learning through an article when teaching cell division to students unfamiliar with microbiology.

In the future I would like to focus studying serious games in participants of different demographics and try to answer the questions mentioned above. I would also like to find out if serious games would increase the rate of learning in all courses or is it just select ones. I would also like to try to find an answer as to why participants felt the article to be more enjoyable than the game and why they would not play the game again. I would also like to find out if the different personalities of people affect the way they play the game and hence affect their learning rate.

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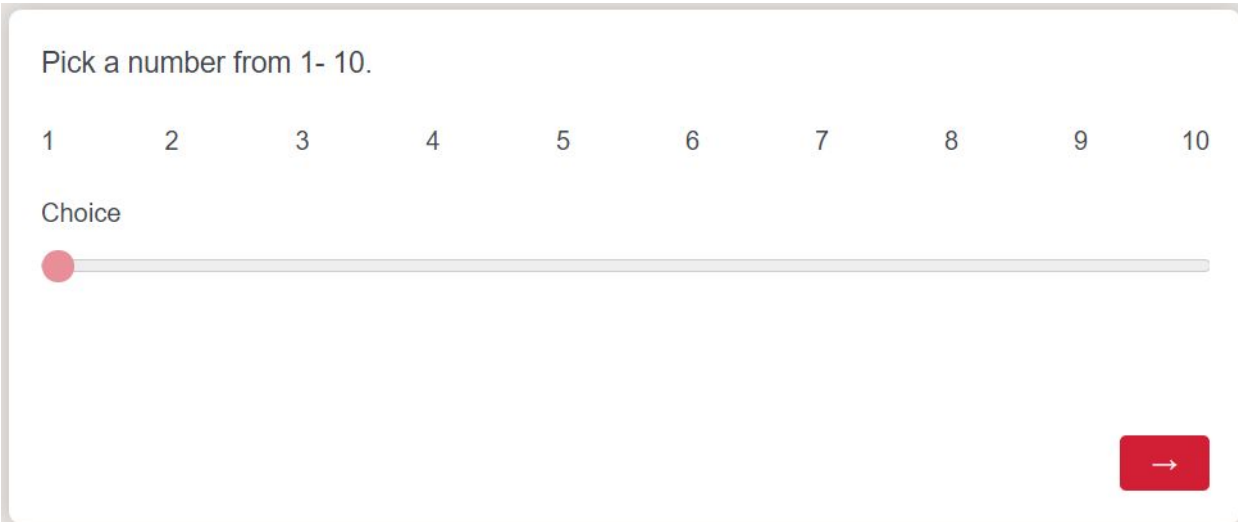
APPENDIX

Survey provided to the participants:

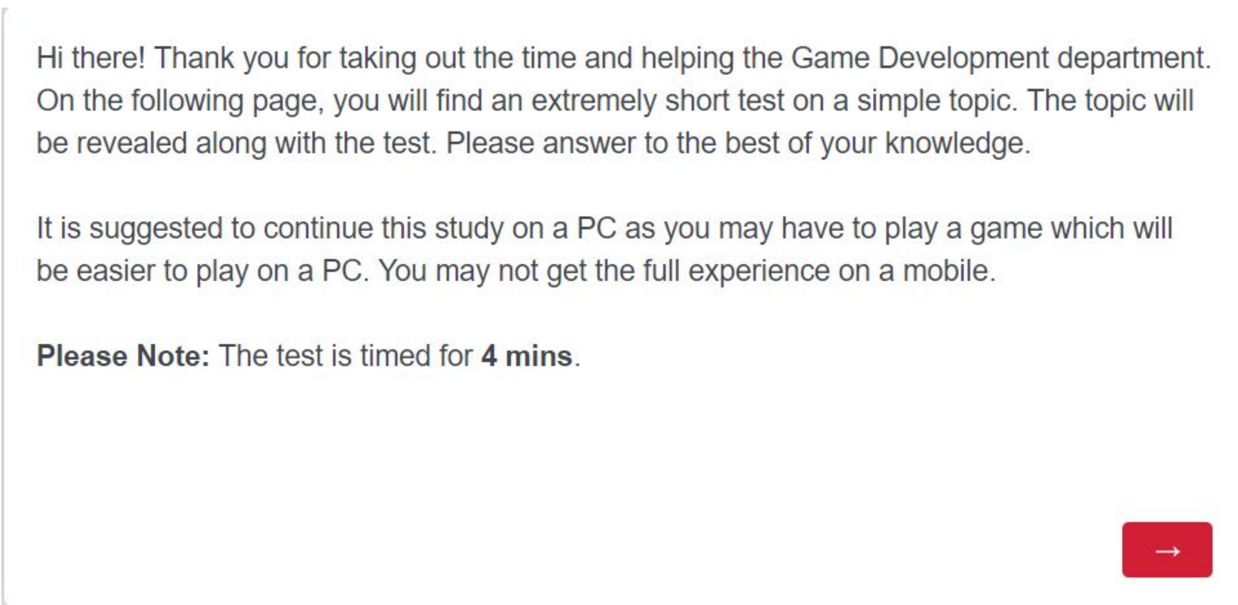


Pick a number from 1- 10.

1 2 3 4 5 6 7 8 9 10

Choice

→



Hi there! Thank you for taking out the time and helping the Game Development department. On the following page, you will find an extremely short test on a simple topic. The topic will be revealed along with the test. Please answer to the best of your knowledge.

It is suggested to continue this study on a PC as you may have to play a game which will be easier to play on a PC. You may not get the full experience on a mobile.

Please Note: The test is timed for **4 mins**.

→

0354

Please answer this short test on the **The Cell Cycle.** Please note your timer has started. You can click next at any time.

Cell Cycle is ___________ (Pick **one** right option)

- The process of how a cell dies
- The process a cell division follows
- The process of how a cell moves
- I don't know
- None of the above

Which cells divide often? (Pick **one** right option)

- Skin
- Liver
- Stomach
- I don't know
- All of the above

In which phase does the cell divide? (Pick **one** right option)

- Synthesis Phase
- Gap 1 Phase
- Mitosis Phase
- Gap 2 Phase
- I don't know

The molecules that control and co-ordinate the cell cycle are _________. (Pick **all** that apply)

- [ ] CDK
- [ ] Chromosomes
- [ ] Spindles
- [ ] Cyclin
- [ ] All of the obove
- [ ] I don't know

A tumor is __________ (Pick **one** right answer)

- ○ Dying cells
- ○ Blood clot
- ○ Diseased organ
- ○ Clump of mutated cells
- ○ I don't know

Which one of the following is the right pattern of the cell cycle? (Pick **one** right option)

- ○ Mitosis → Gap 1 → Gap 2 → Synthesis
- ○ Gap 1 → Synthesis → Gap 2 → Mitosis
- ○ Synthesis → Gap 1 → Mitosis → Gap 2
- ○ Mitosis → Synthesis → Gap 1 → Gap 2
- ○ I don't know

Cells divide ________ (Pick **all** that apply)

- ☐ To replace injured cells
- ☐ To develop a fertilized egg
- ☐ To increase metabolism
- ☐ All of the above
- ☐ I don't know

→

For those who get selected in the Game Control Group, get this message:

CONGRATULATIONS! YOU GET TO PLAY A GAME!!!

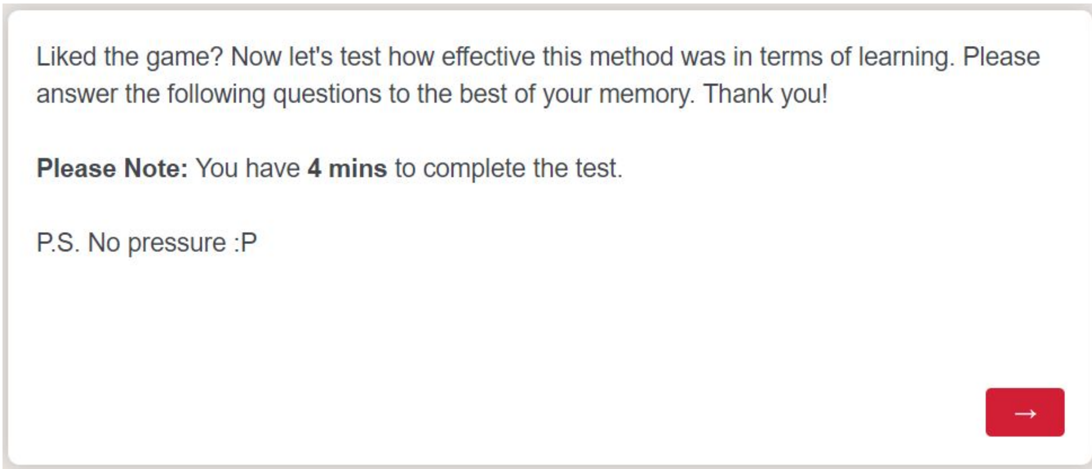
This is a short game which can be completed in under 15 mins. I request you to please finish the game all the way to the end in order to obtain accurate data. You can play the game as many times as you like till you reach the end.

Please open the link in a **NEW TAB** so that you don't lose the the data you have already entered.

After playing, please do come back to this survey and click on the arrow (next) button below. Thank you! Enjoy :)

https://www.nobelprize.org/educational/medicine/2001/cellcycle.html

Once the player's complete the task, they get the following text. It is the same text for both the control groups but for the article the first line is "Liked the article?"

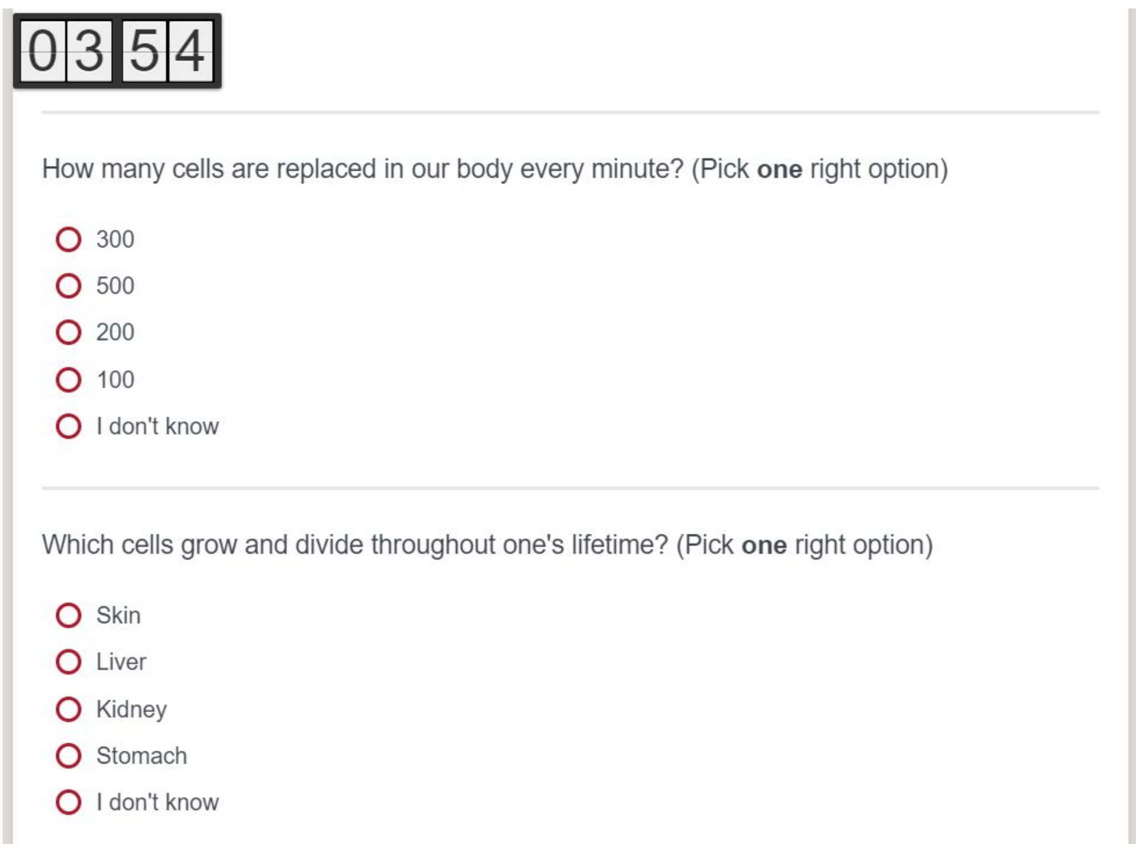

Liked the game? Now let's test how effective this method was in terms of learning. Please answer the following questions to the best of your memory. Thank you!

Please Note: You have **4 mins** to complete the test.

P.S. No pressure :P

→

Then comes the post test:


0354

How many cells are replaced in our body every minute? (Pick **one** right option)

- 300
- 500
- 200
- 100
- I don't know

Which cells grow and divide throughout one's lifetime? (Pick **one** right option)

- Skin
- Liver
- Kidney
- Stomach
- I don't know

What happens when a cell dies? (Pick **one** right option)

- It leaves a gap
- It stays there even though it is dead
- Nothing happens
- It attaches to a living cell and rejuvenates
- I don't know

In which phase does cell division take place? (Pick **one** right option)

- Synthesis Phase
- Gap 1 Phase
- Gap 2 Phase
- Mitosis Phase
- I don't know

What is the order of phases of the cell cycle? (Pick **one** right option)

- Mitosis → Gap 1 → Gap 2 → Synthesis
- Synthesis → Gap 1 → Mitosis → Gap 2
- Gap 1→ Synthesis → Gap 2 → Mitosis
- Gap 1 → Gap 2 → Synthesis → Mitosis
- I don't know

In the Synthesis Phase __________ (Pick **one** right option)

- Cell growth begins
- Chromosomes divide and duplicate
- Cell reaches proper size
- Cell division
- None of the above

The key molecules that control and co-ordinate the cell cycle are ________ (Pick **all** that are valid)

- ☐ CDK
- ☐ Cyclin
- ☐ CDC
- ☐ Chromosomes
- ☐ Spindles
- ☐ I don't know

Errors in chromosomes lead to _________ (Pick **one** right option)

- ○ Cell Division
- ○ Mutations
- ○ Pleiotropy
- ○ Dead cell
- ○ I don't know

Mutated cells that form a clump give rise to ________ (Pick **one** right option)

- ○ Tumor
- ○ Cancer
- ○ Missense
- ○ Heart failure
- ○ I don't know

Cells produced after division are called _________ (Pick **one** right option)

- ○ Daughter cells
- ○ Mutated cells
- ○ Parent cells
- ○ Partners
- ○ I don't know

→

Thank you for playing Control of the cell cycle. I hope you enjoyed the game. Please answer this 2 min survey and you are all set to go. Thank you so much for taking out the time and helping out with this research. Your contribution is very much appreciated. Have a great Day!

→

How much did you enjoy the game?

- A great deal
- A lot
- A moderate amount
- A little
- None at all

Would you play this game again?

- Yes
- Maybe
- No

Do you think you learnt something from this game?

- Definitely yes
- Probably yes
- Might or might not
- Probably not
- Definitely not

Would you have preferred the conventional method of learning? (Books, articles, scripts)?

- yes
- Maybe
- No

Would you recommend this game to your friends and peers?

- yes
- Maybe
- No

DEBRIEFING

In today's world, games are used for almost everything. From entertainment to training and learning. This study is to observe which method out of learning through games and learning through the conventional article/book reading, does one learn more effectively.

Two control groups were created - one who played the game and the other who read the article. The tests and the survey answered will help in the analysis of this research and in reaching a convincing conclusion. This topic of research could change the future of learning. So, thank you for your support and contribution.

A followup survey will be sent in the next few days. So, I request you to type your email ID (@husky.neu.edu, @gmail.com, etc) below.

Email ID: