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Cartoonic and Non-Cartoonic Simulations in Reducing Biology Students' Misconceptions in Cell Division

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Abstract
This study was conducted on a total sample of 136 Malaysian Form 4 Biology students to reduce students' misconceptions in Cell Division using cartoonic and non-cartoonic simulations. Treatment group were taught by non-cartoonic simulation whereas control group were taught by cartoonic simulation. This study was quasi experimental and employed quantitative analysis involving pre achievement and post achievement test. All the data were gathered and analysed using descriptive statistics and inferential statistics such as paired samples t-test and one way ANCOVA. The results showed that the treatment group had significantly reduced misconceptions after taught by non-cartoonic simulation when compared to control group in Cell Division. Hence, findings of this study emphasize the importance of non-cartoonic simulation in reducing Biology students' misconceptions.
Keywords: Biology, Misconception, Cell Division, Cartoonic Simulation, Non-Cartoonic Simulation; Misconception

Introduction

Cell Division is one of the most problematic topic in Biology subject (Baser, 2007; Kara & Yesilyurt, 2008; Lazarowitz & Lieb, 2006; Muhamad, Badioze Zaman & Ahmad, 2010; Saka, Cerrah, Akdeniz, & Ayas, 2006; She & Chen, 2009). Biology subject is one of the science subjects that was offered for Form 4 and Form 5 Malaysian secondary school students. They will learn Biology for two years. Biology subject mainly comprise abstract concepts which students need to be memorize and understand well (Başer, 2007; Ozcan, Yildirim, & Ozgur, 2012). Biology students learn Cell Division topic during Form four.

Cell division process comprise of mitosis and meiosis processes (Goldberg, 2007). Cell division by mitosis and meiosis is a continuous process (She & Chen, 2009) and it also part of the cell cycle. Parent cell divides either by cell division by mitosis or meiosis into new offspring or daughter cells. Cell divides due to the movement and separation of chromosomes until the parent cell

produces new daughter cells (Campbell & Reece, 2005). Mitosis produces two diploid (2n) daughter cells from haploid (n) parent cell. However, meiosis produces four haploid (n) daughter cells from diploid (2n) parent cell because it undergoes two cell division. Daughter cells produce through cell division by mitosis are genetically same as their parent cell. In contrast, daughter cells produce through meiosis cell division are genetically not same as their parent because it consist of half number of chromosomes from their parent cell (Alberts, et al., 2014).

Based on the analysis of the Malaysian Certificate of Education examination (SPM) biology results from the years 2007 to 2011, students have learning problems in Cell Division concepts (Jabatan Pelajaran Negeri Perak, 2012) such as mitosis and meiosis. Previous studies also further emphasized that learning problems in cell division concepts lead to students' poor understandings which then lead to misconceptions (Chattopadhyay, 2012; Knippels, Waarlo, & Boersma, 2005; Nordin & Kamar, 2011; Ozcan, Yildirim, & Ozgur, 2012; She & Chen, 2009) about mitosis and meiosis concepts.

Students have misconceptions and confused between Cell Division processes either by mitosis or meiosis and also unable to identify the type of cell division correctly (Malaysian Examination Syndicate, 2010). Kruger et al. (2006) further emphasized that generally students do not know the whole process of cell division and how the haploid (n) parent cell divides into diploid (2n) daugther cells. Besides that, Lewis et al., (2000) mentioned that students have misunderstandings about the cell, gene, chromosome, how the genetic informations passing down from the parent cell to daughter cells and they unable to distinguish between mitosis and meiosis.

Study findings of Dikmenli (2010) study also reveal that 50% of the sample size; 124 students were had confusion about the mitosis and meiosis concepts. However, majority of the students misinterpret about meiosis concepts than mitosis concepts. Hence, Dikmenli (2010) emphasized in his study that if students' misconceptions didnt overcome yet then it will affect students interest on learning Biology. Before that, educators should take early attempts to overcome students' misconceptions in Biology. Effective teaching and learning activities can overcome students misconceptions (Kruger et al., 2006; Riemeier & Gropengießer, 2008) and can enhance students' understandings in science (Dikmenli, 2010; Olele, 2008).

Less efficient teaching and learning methods such as traditional teaching method in Biology increase students' misconceptions in Biology (Baser, 2007; She & Chen, 2009). Hence, students have learning difficulties in Biology. Traditional teaching method is teacher-centered learning method in which teachers' role more than the students' role in teaching and learning process and it encourage the students to learn through memorization (Ozcan, Yildirim, & Ozgur, 2012). Hence, Kiboss (2002) mentioned that students' understandings cannot be enhance through teacher-centered learning methods.

Integration of information and communication technology (ICT) in education as a instructional tool enhances learning and knowledge (Malaysia Education Blueprint 2013-2025, 2013). Computer simulation found to be effective ICT based teaching and learning methods in enhancing

students' understandings and reducing students' misconceptions in Biology and Cell Division. Students able to visualize how parent cell dividess into new daughter cells through computer simulation while can remember whole process of cell division by mitosis and meiosis easily than words. Mohamad Ali(2007) emphasized that visualizing concepts enable students easily recorded in their memory and they can be recall back easily. Hence, visual based teaching and learning methods have great impacts on students' understanding (Lindgren & Schwartz, 2009) and achievement (Kiboss, Ndirangu, & Wekesa, 2004).

Therefore, cartoonic and non-cartoonic simulations were implemented in Biology teaching and learning process to overcome students' misinterpretation in Biology and Cell Division. Both cartoonic and non-cartoonic simulations are different forms of 3D computer simulations. Cartoonic simulation is desktop virtual reality (VR) simulation whereas non-cartoonic simulation is multimedia simulation. Desktop VR simulation promotes interaction between user and computer screen/ desktop or CRT monitor (Shim, Park, Kim, Kim, Park, & Ryu, 2003). Desktop VR is less interactive and semi-immersive (Shin, 2002) because the user need to use other computer accessories such as keyboard, touch screen and joystick. Hence, desktop VR promotes user to learn in virtual environment (Chen & Teh, 2000, Zhang & Yang, 2009). However, non-cartoonic simulation is multimedia simulation. Multimedia simulation consists of multimedia or graphic elements (Mayer, 2001) such as image/illustration and words. Words including narration, descriptions on the computer screen. Pictures can be in the form of photos, images, illustrations, videos, graphics, animation and simulation.

There were various terms used in previous studies. Multimedia simulation were used as realistic simulation (Elangovan, 2017), 3D visualization (White, Kahriman, Luberice, & Idleh, 2010), computer-based instruction simulation program (Kiboss, Wekesa, & Ndirangu's, 2006), simulation and multimedia resources (Buckley, 2000). However, VR simulation were known as non-realistic simulation (Elangovan, 2017), technology-enhanced curriculum module called Global Warming: Virtual Earth (Varma & Linn, 2012), desktop virtual reality, VR (Ai-Lim Lee, Wong, & Fung, 2010), virtual learning environment, VLE (Pan, Cheok, Yang, Zhu, & Shi, 2006), inquiry-based simulated labs called 'OsmoBeaker' (Meir, Perry, Stal, Maruca, & Klopfer, 2005), educational virtual environment (Mikropoulos, Katsikis, Nikolou, & Tsakalis, 2003) and virtual reality technology (Shim, Park, Kim, Kim, Park, & Ryu, 2003; Shim, Kim, & Park, 2000).

Cartoonic simulation in the teaching and learning of Biology had improved students' understandings and achievement (Elangovan, 2017; Kiboss, & Ndirangu Wekesa, 2006) while non-cartoonic simulation had improved students' performance (Varma & Linn, 2012) and able to overcome their misconceptions in Biology (Elangovan, 2017; Meir et al., 2005). Thus, this study was aimed to identify the impact of cartoonic and non-cartoonic simulations in reducing students' misconceptions in Biology.

Objectives and Research Questions

This study was aimed to determine the effectiveness of cartoonic and non-cartoonic simulations in improving students' understandings and reducing their misconceptions in Cell Division topic. Therefore, this study was designed to seek answers to the following research questions:

Do cartoonic and non-cartoonic simulations are effective in improving Biology students' misconceptions and their understandings in cell division?

Methodology

Research Design

This study is a quasi-experimental design and were used quantitative research method to identify Biology students' misconceptions in Cell Division using cartoonic and non-cartoonic simulations based teaching and learning methods. The variables involved in this study are students' misconceptions using cartoonic and non-cartoonic simulations in Biology (dependent variables) and Biology teaching and learning methods: cartoonic and non-cartoonic simulations (independent variable).

Research Sample

A total of 136 Form 4 Biology students were randomly selected from two secondary schools in Perak, Malaysia and were taught using cartoonic and non-cartoonic simulations based teaching and learning methods. These secondary schools have been identified as low-performing schools based on the analysis of continuous five years of Biology SPM results (Jabatan Pelajaran Negeri Perak, 2012). These two schools were make sure that have adequate biology students, biology labs, computers, projectors, big LCD screen, speakers and other similar facilities which needed for this study.

Total sample of Biology students were classified into treatment (68 students) and control (68 students) groups. Treatment group was learnt using non-cartoonic simulation whereas control group was learnt Cell Division topic using cartoonic simulation for three weeks by more experienced Biology teachers. The Biology teachers also were well briefed about the teaching and learning process using cartoonic and non-cartoonic simulations.

Research Instrument

Cell Division test was administered to both group treatment and control group before (pre achievement test) and after (post achievement test) the intervention using cartoonic and non-cartoonic simulation. Both pre achievement and post achievement test consisted of total of 18 objective questions which were adapted from the collection of past years' SPM biology question papers and also from biology reference books. These 18 objective questions were constructed based on three important concepts of Cell Division topic: cell cycle, mitosis and meiosis. Both pre achievement and post achievement test consisted of the same question items but were arranged the items in random order.

Teaching and learning of Cell Division

Cartoonic and non-cartoonic simulations based teaching and learning method are based on the constructivist perspective and emphasized student centered learning. Biology teachers were well trained to use cartoonic and non-cartoonic simulations before they teach to the students. Both treatment and control group students were given pre test before the interventions using cartoonic and non-cartoonic simulations. After that, Biology teachers was projected cartoonic and non-cartoonic simulations on the LCD screen.

Students' role more in this teaching and learning method than the teachers. Teachers act as facilitator. Students actively engaged in learning process using cartoonic and non-cartoonic simulations. During projection of these 3D computer simulations, students visualize how cell division process either by mitosis and meiosis occur and understand by relate with current existing knowledge about cell division process. Students visualize cell division process many times. Students able to record the visual form of learned concepts in their memory than words and able to recall back when needed. Teachers ask quetions regarding cell division. Students were collaborate with their friends and answering the questions while visualizing cartoonic and non-cartoonic simulations. Hence, students' understandings increase and able to improve their misconceptions about cell division.

Teaching and learning process for both treatment and control group were same but differed in term of computer simulation. Treatment group was learned using non-cartoonic simulation whereas control group was learned using cartoonic simulation for three weeks. The lessons were conducted for 2 hours and 40 minutes per week. These two simulations are 3D based but differed in term of their visual structure. Post achievement test was administered to both treatment and control group immediately after the interventions using cartoonic and non-cartoonic simulations. Figure 1 represents the screenshots of a cartoonic simulation (multimedia simulation) and Figure 2 represents the screenshots of non-cartoonic (desktop VR) simulation for cell division;

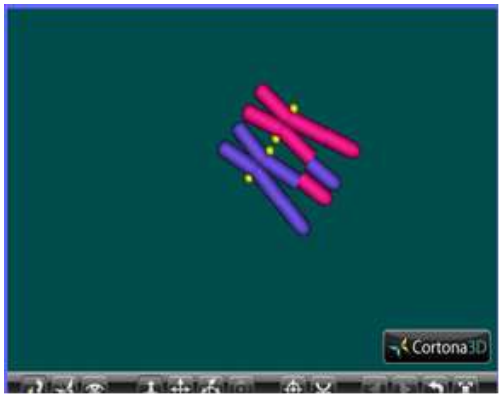

Figure 2. *Screenshots of cartoonic simulation about Cell Division by meiosis: Prophase I stage*

Figure 2. *Screenshots of non-cartoonic simulation about Cell Division by meiosis: Prophase I stage*

Results and Discussion

This study was conducted to identify the effects of cartoonic and non-cartoonic simulations in improving students' understandings and reducing their misconceptions in Cell Division topic. Form four Biology students' misconceptions were identified through students' understandings test; pre achievement test (understandings before the intervention) and post achievement test (understandings after the intervention). Students' misconceptions were identified through students' low and high scores in understandings test. Students' low scores reveal that students have more misconceptions and poor understandings about the Cell Division concepts. However, students' high scores reveal that students have less misconceptions and better understandings about Cell Division concepts. Findings of this study were analyzed through mean scores (descriptive statistics) and paired samples t-test and one way ANCOVA (inferential statistics) methods using SPSS version 16.0 software.

Research Question

Do cartoonic and non-cartoonic simulations are effective in improving Biology students' misconceptions and their understandings in cell division?

This research question was analyzed using descriptive (mean scores) and inferential statistics such as paired samples t-test were used to compare the extent of Biology students' misconceptions in Cell Division concepts before and after intervention using cartoonic and non-cartoonic simulations. Analysis of the descriptive statistics is shown in Table 1 that both the treatment and control groups had less misconception after learned using non-cartoonic and cartoonic simulations. Treatment group students who learned using non-cartoonic simulation mean score was increased about 3.28 in the post achievement test (*M* = 12.60) than the pre achievement test (*M* = 9.32). Control group students who learned using cartoonic simulation mean scores also was increased about 2.70 in post achievement test (*M* = 10.79) than the the pre achievement test mean (*M* = 8.09). Students' better performance in post achievement test revealed that Biology students' misconceptions had reduced after the intervention using cartoonic and non-cartoonic simulations.

Table 1
Descriptive Statistics for Control and Treatment Groups

Groups	Test	n	M	SD
Treatment	Pre achievement test	68	9.32	1.86
	Post achievement test	68	12.60	1.89
Control	Pre achievement test	68	8.09	1.92
	Post achievement test	68	10.79	1.85

Findings of this study are supported by findings of previous studies. Previous studies regarding cartoonic (Elangovan, 2017; Varma & Linn, 2012; Meir et al., 2005; Mikropoulos et al., 2003; Shim et al., 2003, Shim, Kim, & Park, 2000) and non-cartoonic simulations (Elangovan, 2017; White, Kahriman, Luberice, & Idleh, 2010; Kiboss, Ndirangu, & Wekesa, 2006;) in Biology topics such as Cell Division, Protein, greenhouse effect and global warming, passive transport topics such as

diffusion and osmosis, plant cells and photosynthesis, eye structure and function showed that both cartoonic and non-cartoonic simulations had enhanced students' understandings and achievement. Better understandings lead to an improvement in students' misconceptions in Cell Division topic.

In addition, analysis of paired samples t-test (inferential statistic) was revealed that there was a significant difference exists between control and treatment group students' misconceptions and understandings in the understanding test after intervention (post achievement test) than the pre achievement test. Analysis of the paired samples t-test is shown in Table 2;

Table 2
Analysis results of Paired Samples T-Test for Control and Treatment Groups

Groups	Test	M	SD	t	df	Sig. (2-tailed)
Treatment	Pre achievement test Post achievement test	9.32 12.60	1.86 1.89	-19.74	67	.00
Control	Pre achievement test Post achievement test	8.09 10.79	1.92 1.85	-12.15	67	.00

Based on analysis shown in Table 2, treatment group students were significantly had fewer misconceptions in post achievement test (M=12.60, SD=1.89) when compared to pre achievement test (M=9.32, SD=1.86). The differences between pre achievement and post achievement test are significant [$t(67) = -19.74$; $p < 0.00$)]. Similarly, control group students also had fewer misconceptions in post achievement test (M=10.79, SD=1.85) when compared to pre achievement test (M=8.09, SD=1.92). The differences between pre achievement test and post achievement test of control group are significant ($t(67) = -12.15$; $p < .00$). Both control and treatment group were had higher post achievement test means when compared to pre achievement test. This result showed that both control and treatment group have fewer misconceptions after the intervention. Treatment group have mean score differences between pre achievement test and post achievement test about 3.28. Similarly, control group students also have mean score differences between pre achievement test and post achievement test about 2.70. However, treatment group students' results revealed that there were bigger differences between pre achievement test and post achievement test mean scores. Hence, treatment group students have improved their misconceptions and understandings about Cell Division concepts.

Besides that, inferential statistics such as one way ANCOVA was used to identify the effectiveness of cartoonic and non-cartoonic simulations in improving misconceptions about Cell Division. Pre achievement test scores were used as covariate whereas the post test scores were the dependent variable of this study. Analysis of one way ANCOVA was shown in Table 3;

Table 3
Analysis results of One Way ANCOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Covariate (Pre achievement test)	185.609	1	185.609	86.987	.000
Groups	33.134	1	33.134	15.529	.000
Error	283.788	133	2.134		
Total	580.64	135			

Based on Table 3, analysis results of one way ANCOVA reveal significance difference [F(1, 133) = 15.53; p = 0.00)] between cartoonic and non-cartoonic simulations in learning Cell Division concepts. Furthermore, treatment group (M = 12.22) those learnt using non-cartoonic simulation gained high estimated marginal mean scores in post achievement test (understandings after intervention) than the control group (M = 11.18) those learnt using cartoonic simulation. Better understandings of treatment group in post achievement test showed that they had improved misconceptions in Cell Division concepts than the control group after the intervention using non-cartoonic simulation. Estimated marginal means scores of control and treatment group students are shown in Table 4;

Table 4
Estimated Marginal Mean Scores of Post Achievement Test

Groups	Mean	Std. error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental group	12.218[a]	.182	11.858	12.578
Comparison group	11.179[a]	.182	10.819	11.539

Treatment group students' understandings in the post achievement test reveal that they have fewer misunderstandings than the control group. Estimated marginal mean scores also further emphasized that there is a difference about 1.04 between control and treatment group students' understandings. The estimated marginal mean scores and also analysis results of one-way ANCOVA reveal that the treatment group who taught with non-cartoonic simulation has fewer misconceptions about Cell Division when compared to control group who taught with cartoonic simulation. Thus, non-cartoonic simulation is more effective in improving students' misconceptions and understandings in Cell Division and Biology when compared to cartoonic simulation..

Njoo and de Jong (1993) said that non-cartoonic simulation is more effective because of the nature of non-cartoonic simulation that consists of movement, colour, graphic representations, animations and simulations. Furthermore, findings of previous studies regarding cartoonic simulation (VR simulation) showed that students have high interest when learning with VR simulations (Shim et al., 2003; Shim, Kim, & Park, 2000). Meir et al. (2005) said that students'

active engagement while visualize the cell division processes enhance students' understandings and reduced their misconceptions about diffusion and osmosis. Findings of previous studies revealed that cartoonic and non-cartoonic simulations have positive impacts in learning Biology. However, Mikropoulos et al., (2003) mentioned that cartoonic simulation (desktop VR simulation) was unable to promote real learning environment whereas non-cartoonic simulation (multimedia simulation) create real learning environment. Thus, findings of this study showed that non-cartoonic simulation is more effective teaching and learning method in enhancing students' understandings and reducing misconceptions in Cell Division and Biology.

Conclusion

Cartoonic simulation (desktop VR simulation) and non-cartoonic (3D multimedia simulation) had improved Biology students' understandings and their misconceptions about Cell Division concepts. Thus, non-cartoonic simulation is known to be more effective teaching and learning method when compared to cartoonic simulation in reducing misconceptions in Cell Division. Even though, there are some recommendations for future study. Biology teacher's effect was not fully controlled in this study because not same teachers taught to all the students who selected as research samples since the students were selected from two different secondary schools. Teacher's effect might be affecting the students' post achievement test scores. Thus, in future study, same teacher have to involve in the intervention using cartoonic and non-cartoonic simulations to examine the effectiveness of cartoonic and non-cartoonic simulations. Moreover, this research findings would be added advantage to the Ministry of Education Malaysia since the implementation of ICT in teaching and learning emphasized as one of the important shift in education transform system to ensure the quality of learning (Malaysia Education Blueprint 2013-2025, 2013).

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