Student Perceptions of Interactive Whiteboards in a Biology Classroom

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Abstract

The aim of this paper is to design interactive teaching strategies with Interactive White Boards (IWB) and examine their effectiveness in teaching biology. Following the trend of integrating the IWB in teaching, in this study we tried to stress the advantages of IWB to provide better and effective teaching of biology in schools.

The research was conducted with students from third year in two secondary schools in Stip. Students were divided into two groups. IWB-group (n = 35) – which used white board in biology classes and T-group (n = 35). T-group was the control group which applied classical teaching where the teacher used Microsoft PowerPoint slides on the screen.

The results showed that compared with classical training, IWB is more effective in presenting topics of biology, or, more specifically, the theme "cell division" which was processed with both groups of students. Some limitations and areas for improvement were also noted. These results can be used to inform educators on possible applications of the IWB's use not only in biology but in other school subjects as well.

Key words: ICT, Interactive White Boards, biology, cell division, student perceptions.

СТУДЕНСКА ПЕРЦЕПЦИЈА ИНТЕРАКТИВНЕ БЕЛЕ ТАБЛЕ НА ЧАСОВИМА БИОЛОГИЈЕ

Апстракт

Циљ овог рада је да дизајнира интерактивне наставне стратегије са интерактивном белом таблом (ИБТ) и да испита њену ефикасност у наставибиологије. Пратећи тренд интегрисања ИБТ у настави, у овом истраживању покушали смо да истакнемо предности ИБТ у обезбеђивању боље и ефикасне наставе биологије у школама.

Истраживање је спроведено са ученицима треће године у две средњешколе у Штипу. Студенти су били подељени у двегрупе: ИБТ - група (н=35) – који су користили белу таблу на часовима биологије, и Т-група (н=35) која је била контролна група и примењивала је класичну наставу где наставник користи Microsoft PowerPoint слајдове на екрану.

Резултати су показали да је, у поређењу са класичном наставом, ИБТ ефикаснија у представљању тема из биологије, или, тачније, теме „Деоба ћелије" која је обрађена са обе групе студената. Евидентирана су нека ограничења и области које треба побољшати. Ови

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резултати се могу користити за информисање едукатора о могућим апликацијама коришћења ИТБ не само у биологији, већ и у другим школским предметима.

Кључне речи: ИКТ,интерактина бела табла, биологија, деоба ћелије, студентска перцепција.

Introduction

Subjects that are being taught in biology classes in high school such as cell division, photosynthesis, cellular respiration, food chain and evolution are topics that are difficult to study and learn. Teachers and students believe that the topic Cell division is the most difficult topic for learning of all the topics. Many similar studies have shown that students of different ages and in different classes have insufficient knowledge about cell division (Lewis et all,2000; Lewis and Wood-Roinson, 2000; Smith, 1991). Lewis (2000) suggested that students have difficulty in understanding the process of cell division because this topic requires good prior knowledge of the basic structures of cell organelles that participate in the process of cell division. If they were shown using a pictorial and understandable way, it would be much easier for students to understand it. So teaching should emphasize the dynamic nature of cell division using a variety of teaching aids such as pictures, movies and video clips to demonstrate changes of chromosomes in different stages of cell division and make models of chromosomes which will help them overcome the difficulties in learning.

The research was conducted with students from the third year in two high schools in Stip. Students were divided into two groups. IWB-group (n = 35) - which in biology classes used a white board and T-group (n = 35). T-group was a control group where classical teaching was applied with the teacher teaching using Microsoft PowerPoint slides on the screen. In the group that during the teaching of biology used the whiteboard - IWB group integrated teaching was applied.

The results showed that compared with the classical ICT - integrated teaching, IWB is more effective in improving the teaching of topics in the area of biology, or more specifically, the topic Cell division which was processed with both groups of students.

The main advantages of IWB mentioned in literature and their potential in teaching biology are explained as follows (Gloveretal., 2005; Holmes, 2009; Northcoteetal., 2010; Smithetal., 2005; Walletal. , 2005):

Advantage 1. Flexibility and variability

IWB can be used in teaching students of different ages and for different topics. Its features include notes, reviewing of material, saving drawings and text, movement of the planned object and focusing. It can improve flexibility and mobility in the classroom. Therefore, IWB is suitable for classes in teaching biology in secondary schools. Moreover, IWB can focus on specific content and can expand multimedia objects based on teacher and student needs. Notes about the content can also be made via IWB screen. In addition, teachers can record the teaching process (including the notes) and interactions with students for later review.

Advantage 2. Multimedia / Multimodal Presentation

IWB represents a new integrated connecting of all teaching materials. A multimedia presentation can attract the attention of students and help them understand abstract concepts. In teaching biology, the visual nature of IWB presentations can enhance student learning by delivering micro or dynamic representations of abstract concepts such as the process of cell division or structures or functions within the body such as blood circulation. IWB also supports multimedia and multimodal presentation. Most presentations can be simultaneously displayed on the screen to meet the needs of students with different learning styles.

Advantage 3. Improving teaching efficacy

Teachers can display many multimedia resources on the IWB to improve their teaching efficacy. For example, the structure of chromosomes can be displayed with images; video or 3D models to help students make a model of the chromosome. In addition, students can use the IWB to enhance and facilitate their learning process. Teachers can design learning activities for IWB, which can help students to actively think and work on IWB. For example, teachers may provide incomplete moving charts for the process of cell division for students to finish through discussion. Teachers can also provide students with images of changes in chromosomes in each phase of cell division and align images in correct layout and explain how the number of chromosomes and DNA is modified.

Advantage 4. Planning and development of resources

IWB has a great teaching resource material relying on the database where teachers can access a variety of animations and music on various topics, such as the anatomy of a frog, and use it in the development of digital materials for teaching activities.

Advantage 5. Improving students' skills to use ICT

Teachers can use the IWB to help students engage in learning better. Students can improve their skills in using ICT through the use of the white board in teaching biology.

Advantage 6. Interactivity and participation during class

Interactivity is provided with IWB and can improve the interaction in the classroom and make students and teachers feel closer to each other. They may have visual contact using a laptop and the teachers are able to control the class. Moreover, IWB is more beneficial in teaching courses that include survey (research) activities and request an increased participation of students.

Advantage 7. Improving students' motivation for learning

The ability of IWB to dynamically integrate audio and visual presentations can make the teaching activities more vivid and realistic. Compared to standard 2D presentations and textbooks, IWB can better attract the attention of students and improve their motivation to learn.

Advantage 8. Enhancing the understandings of students

IWB is characterized by visual nature and supports multiple displays, which not only attracts the attention of students, but also enhances their understanding of the topics that are covered. For example, IWB can simultaneously show 2D screen images of the structure of

chromosomes and 3D video demonstrations of the relationship between chromosomes, genes and genetic information. This can not only improve the understanding of students with different learning styles, but can also improve their ability to interpret the relationship between the 2D images and 3D videos with information they transfer.

The above mentioned advantages of integrating the IWB in teaching biology in secondary schools show that the introduction of IWB in class will provide teachers with a way to present the dynamic nature of cell division, and the relationship between cells, chromosomes, genes and genetic information with multimodal and multimedia presentations. Moreover, with the high interactivity of the IWB students participate in learning and promoting learning motivation. In this research we created digital teaching materials and activities that IWB uses for the learning of cell division, in order to examine the effect of integration of IWB in the study of cell division.

Methodology

The research covered two secondary schools in the municipality of Stip with a total number of respondents - 70 students. They were divided into two groups. The first group included 35 students who were taught biology with a Smart board through integrated and interactive teaching, and the second was the control group - 35 students (n = 35) who were taught biology by applying traditional teaching where the teacher taught with Microsoft PowerPoint slides on the screen.

InteractiveIWB -SmartBoard^{TM}

The IWB used in this study is the SmartBoard^{TM} that uses analog resistive technology. It is connected to a notebookor a computer through a USB cable, and the notebook or computer is connected tothe projector. Signals of the projector are projected onto the IWB soby adjusting the IWB,teachers can operate the computer by touching the IWB, as shown in Figure 1. This interactive WB canimmediately save the written texts, drawings and other messages on the IWB panel to theconnected computer.

Figure1. Interactive Whiteboard system structure and operation

Digital teaching materials and teaching method

This study is focused on the topic "Cell division" in teaching biology in a high school in the Republic of Macedonia. The teaching contents for this topic cover three subtopics: "Chromosomes and their significance", "Role of mitosis", and "Meiosis and sexual life cycle."The teaching materials for‘chromosomes and their significance’ are focused on the following concepts: chromosomes are located in the nucleus; chromosomes contain hereditary material - genes to identify inherited personality characteristics; the number of chromosomes varies in different species but it is always strictly constant for a certain species, homologous chromosomes."Role of mitosis," "Meiosis and sexual life cycle" aim at enabling students to understand when mitosis and meiosis happen in a cell, and why they are important for all life in general.

Digital teaching materials that were used by teachers of biology classes in the study of these teaching topics were mainly pictures, photographs and Adobe Flash animations. The materials used in both groups incorporate the same concepts and teaching is carried out by the same teacher. The main difference is that in the IWB group digital instructional materials can be used on NoteBook^{TM} software which is made possible by SMART^{TM} Technologies.Furthermore, teachers can communicate with students through the IWB screen. In the control group, digital instructional materials are presented in a classic way of teaching, presenting PowerPoint slides through the projector screen, and the interaction between the teacher and students is limited to verbal communication. The teaching methods in the experimental and control group are explained below.

Teaching methods for the experimental group

Students have prior knowledge of the cell from previous lectures. They know that the nucleus is related to heredity but they do not understand the contents of the structures responsible for transferring hereditary information from generation to generation. Lewis (2000, b) in their research found that students did not understand the relationship between the cell, chromosomes and genetic information. If students need to develop a coherent conceptual objective to better understand the genetics and inheritance, they first must well understand the relationship between the basic structures - cell nucleus, chromosomes and genes.Hence, in the topic "Chromosomes and their Significance" the teacher enables students to understand the relationship between the cell nucleus, chromosomes, genes and genetic information via two-dimensional and three-dimensional microscopic imaging. Likewise, aiming at students' better understand of the relationship between the cell nucleus, chromosomes and genes, the teacher performs activities with which he/she invites students to answer the questions and move on to the IWB collaborative matches of the genetic structures.This section also includes an explanation of the structure and function of the DNA. The teacher also implements activities for students to work together to identify the relationship of blood between the child and its parents through their previous knowledge of DNA copies, and to explain the reasons for their identicalness (Figure 2).

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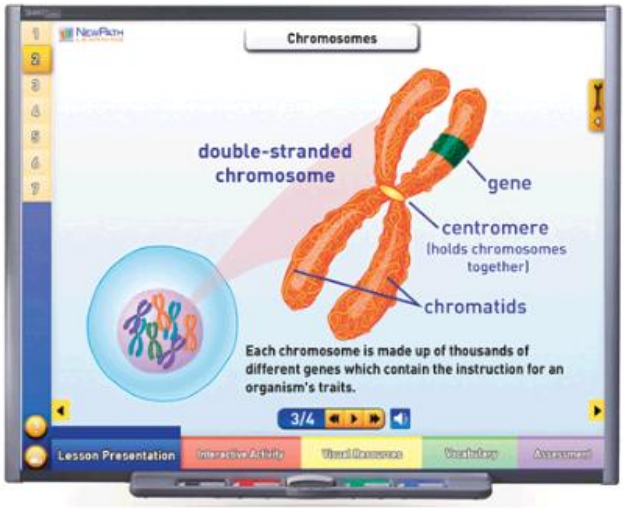

Figure 2. Students learn inIWB groups

Students can also resolve misunderstandings about sex chromosomes (X, Y chromosomes),they directly compare men's and women's karyotypes, differences between themselves, and the number of chromosomes. In addition, students have access to Adobe Flash animations to find out the number of chromosomes. After comparison, they may conclude that different types have different numbers of chromosomes and that the number of chromosomes does not imply a hierarchy of types (Figure 3).Finally, the concepts of homologous chromosomes, polyploidy and gene alleles are displayed through human karyotypes. By dragging and making separate homologous chromosomes together through IWB, students will gain a better understanding of the concept. In order to enable students to clearly identify differences in alleles, this information is represented by using images. Moreover, the concept of ploids is represented by students who compare karyotypes of human somatic and reproductive cells.

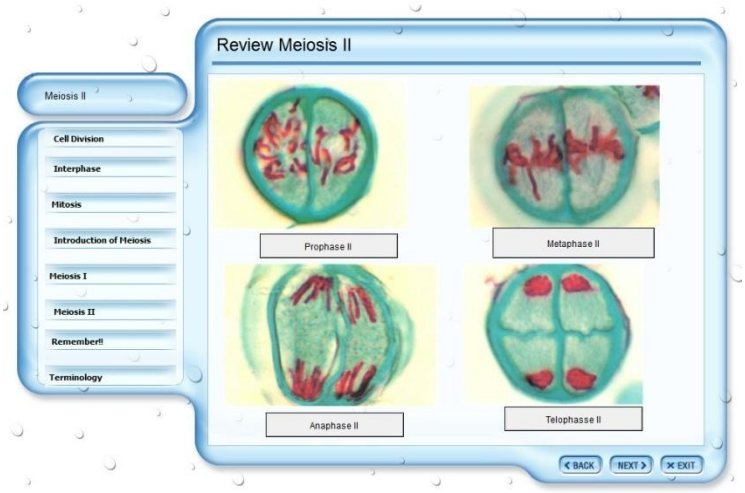

Figure 3. The teaching materials – examples from a teaching lesson, Stavreva Veselinovska, S., 2012)

During the processing of the teaching content "Mitosis" teaching activities are used to help students understand the importance and the process of mitosis. The IWB screen is divided into two parts. The left part presents the significance of mitosis, the process by which a cell is divided into two identical cells. On the right side, IWB shows the process of mitosis but it does not show how chromosomes change in the nucleus. Instead, students are enabled to actively think about the changes on chromosomes in mitosis, and the teacher applies instructional

activities with which students will be forced to answer questions about the changes of chromosomes in each stage.

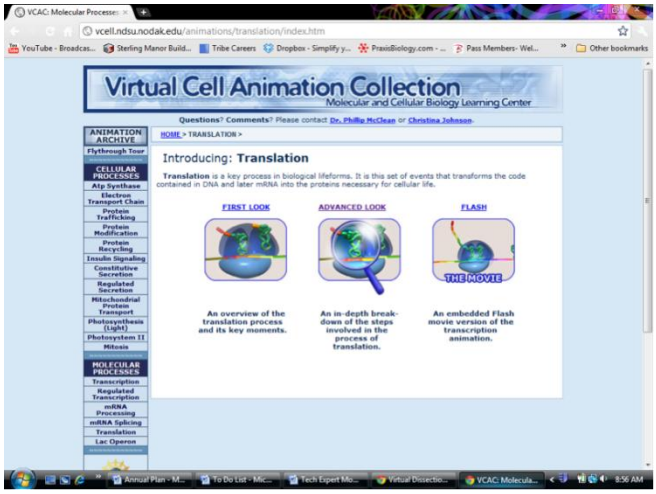

Figure4. Screenshot of teaching materials (Stavreva Veselinovska S., 2012)

Furthermore, to clarify the students' misunderstanding of terminology they will learn terms, including "chromosomal duplication", "separation of sister chromatids" and "one cell divides into two identical cells" (see step 4 in Figure 4).

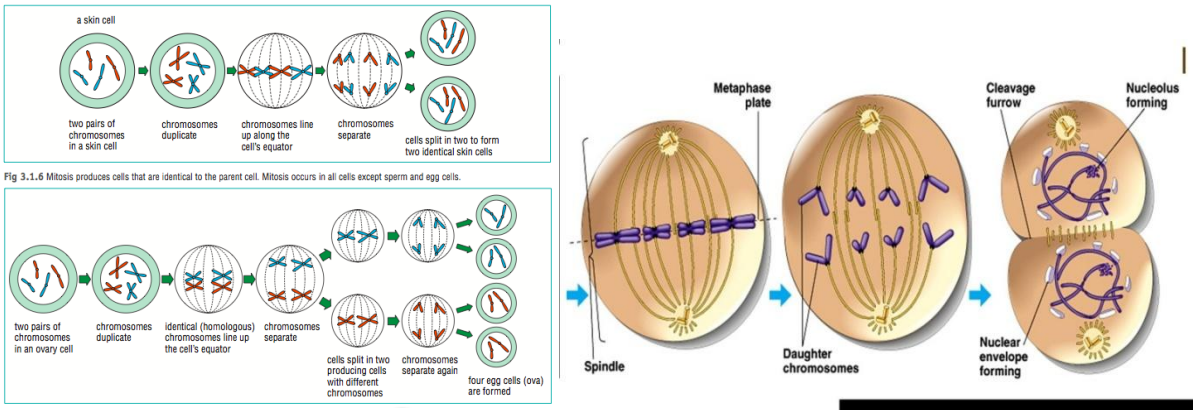

Figure. 5. The four steps of teaching the concept of mitosis in IWB group. The big rectangles in this figure are the masks for the correct answers – example from a teaching lesson, Stavreva Veselinovska S., 2012 .

After that, in order for the students to get a deeper understanding of changes in ploidies, DNA quantity and the number of chromosomes, a picture of each stage of mitosis is projected on the IWB display for students to work together in determining the process of mitosis in

subsequent stages (prophase, metaphase, anaphase, telophase) (Figure 5), and then they draft diagrams of changes in chromosomes, DNA molecule and the number of chromosomes (see section C in Figure 5).

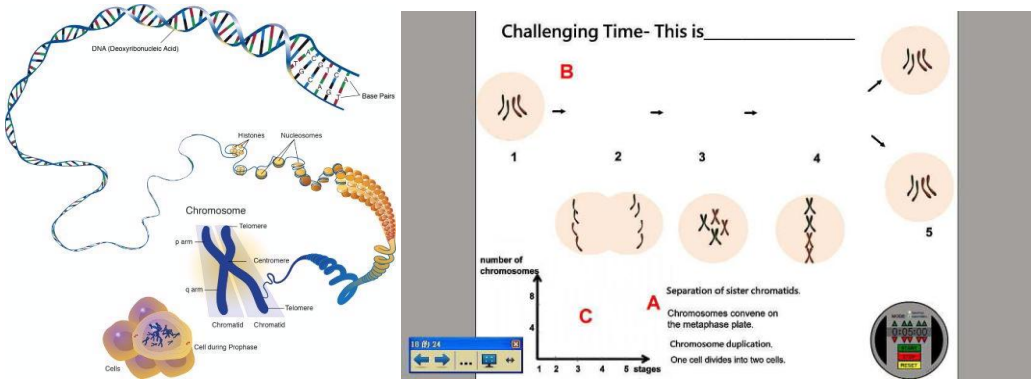

Figure 5. Screenshot of the teaching materials for the concept of mitosis in IWB group

In "Meiosis and sexual life cycle" teacher also introduces teaching activities to enable students to understand the importance of meiosis and when and where it happens. Human karyotypes are used to help students understand that if meiosis does not occur in gametes before fertilization, there can be a problem on tetraploidies. Then students learn about meiosis using methods similar to those listed above.Students should identify the following concepts of meiosis: "chromosomes replicate once, but divide twice", "there are four daughter cells" and "sister chromatids divide during anaphase II". They made notes on the IWB screen and notice the concepts that meiosis is the main cause of genetic variation in the sexual life cycle. They also seek to demonstrate changes in the number of chromosome sets, the number of chromosomes and DNA quantity.Finally, to enable students to distinguish between mitosis and meiosis, the teacher presents two parallel cell divisions, mitosis and meiosis, sexual and asexual reproduction on the IWB screen. Their similarities and differences are presented by the students.

Application of teaching methods in the control group

Digital teaching materials used in the IWB group and T group include the same concepts presented by the same teacher. The main difference is that in the IWB group digital teaching materials can be used for teaching on the IWB, while in the T group these digital instructional materials are presented in a classical way using the projector for Microsoft PowerPoint slides on the screen and the interaction between the teacher and the students is limited to verbal

communication. In other words, the experimental and control group are presented the same instructional materials in the same order. The only difference is that in the experimental group, the students are allowed to work together on the smart board during class. In the control group, students answer questions verbally during the teaching activities, and the teacher presents the teaching materials using PPT slides one by one.

Therefore, in the subtopic “Chromosomes and their significance" all teaching materials are designed to allow students in the control group to learn the basic structures through images. However, in the experimental group, students compete to answer questions and make a connection between the basic structures on the smart board.In the control group, after the teacher asks the questions, students compete to answer and then the teacher uses simple animations embedded in PPT slides to present the relationship between the basic structures. Once students answer the questions, the teacher shows the correct answer with animations included in PPT slides. In addition, the teacher directly demonstrates Adobe Flash animations indicating that the location, content and number of chromosomes varies in different species.

In the subtopic "The role of mitosis" teaching activities are used to help students understand the importance of mitosis. The screen of the PPT presentation is divided into two parts. The left side of the screen shows the importance of cell division - one cell is divided into two identical cells. The right side of the screen shows a diagram of the process of mitosis, but not the changes of the chromosomes in the nucleus.After implementing educational activities with students, the teacher shows animations included in the PPT slides to show how chromosomes and terminology change at each stage in the process of mitosis (Figure 6).To give students a deeper understanding of the changes in the number of chromosome sets, the number of chromosomes, and the quantity of DNA, the teacher also presents PPT slides and animations that are embedded in PPT slides to show the process of mitosis and changes DNA and chromosomes after carrying out the educational activities with students.The teacher teaches the subtopic "Meiosis and sexual life cycle" in the same way as the subtopic "Role of mitosis." The table also shows the animations embedded in PPT slides after the teacher completes the teaching interactive activities with his/her students.

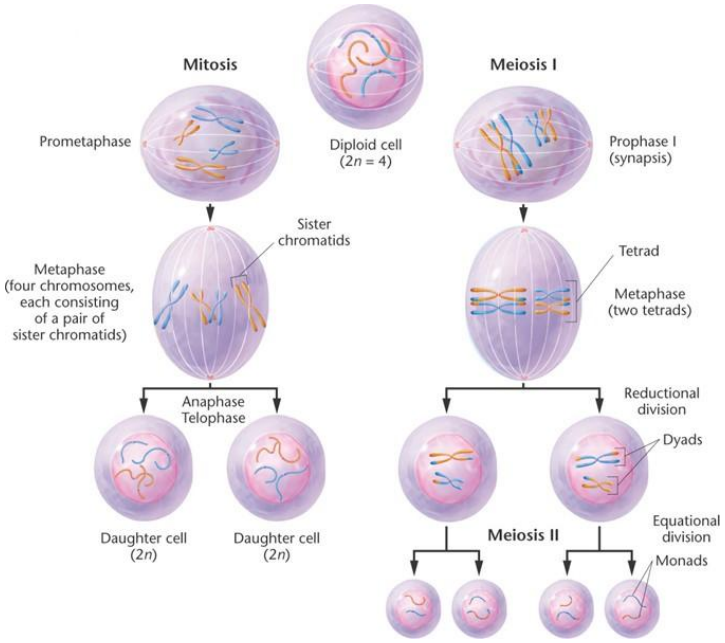

Figure 6. Screenshot of the teaching materials for the concept of mitosis in the T-group

Comparison of teaching methods applied in a biology class with IWB technology and the classical technological-integrating teaching method

Differences between the teaching method withIWB and the T-group are:

*Teaching subtopic:*Chromosome and its significance

IWB group:

- In addition tousing images to present the basic structures, students also guess image sof basic genetics tructures competing in answering questions touching IWB,color in gorcircling with pens in different colors which enhances their impressions and understanding sof the concepts and terminology.
- Karyotypes of men and women are simultaneously shown on the IWB screen which is used to help students understand the differences of sex chromosomes.
- Students can actively play Adobe Flash animations with which their impressions and understanding of concepts and their ICT skills can be improved.

T - group:

- While PPT slides can present many images and animations, the animations included in PPT slides are displayed in a linear manner after the teaching activities.

- The interaction of the teacher with students is limited to verbal communication, all software operations are carried out by teacher.

*Teaching subtopic***:** Role of mitosis

IWB group:

- The big Screen of the IWB is divided into two parts so that it will be easier to show the information to the students in order to think about and complete each phase of mitosis and to allow them to clearly learn the associatedterminology
- To improve students' understandings, the activities are designed so that students finish the answers to the questions asked, work with IWB to complete the process of mitosis and to draw the changes in chromosome number, quantity of DNA and chromosome sets.

T - group:

- Animations included in ppt slides are displayed in a linear manner after the teaching activities.
- The interaction of the teacher with students is limited to verbal communication, all software operations are carried out by the teacher.

*Teaching subtopic:*Meiosis and sexual life cycle

IWB group:

- The teaching method is the same as the one used for teaching mitosis, but IWB can provide fast browsing and it is convenient to make notes on IWB screen to allow students to clearly understand the difference between the two types of cell division.
- Students are allowed to write on the IWB and compare mitosis with meiosis and sexual reproduction so that their understanding can be improved.

T - group:

- Animations included in ppt linear slides are displayed in a linear manner after the teaching activities.
- The interaction of the teacher with students is limited to verbal communication, all software operations are carried out by the teacher

Research

To understand how the integration of IWB in teaching affects the effectiveness of teaching in secondary schools in the Republic of Macedonia, this research uses a quasi-experimental design to divide the participants into the experimental group (IWB group) and the control group (T-group). The IWB group is taught in a teaching environment that is integrated with the IWB, while the control T-group is taught using classical ICT, where the teaching is performed using Microsoft PowerPoint slides with a traditional projector screen through a projector. However, both groups are taught by the same teacher. Beforeteaching, studentshavea pre-testing of the overall assessment in order to understand the students' initial knowledge. Then students receive five classes in which information technology is integrated into instruction. After the five classes, students take a post-test for the overall assessment.

Collecting data and analysis

The collected data are quantitative data, including pre-test and post-test results of the overall assessment. To examine how to integrate smart whiteboard in teaching in secondary schools for the topic cell division and the effectiveness of student learning, this study uses two different types of techniques for data analysis. First, to examine the effectiveness of two different types of teaching methods, ANCOVA was conducted to calculate the overall assessment.The results of the pre-test of the overall assessment is taken as an independent variable in two different types of teaching methods as a fixed factor and the results of the post-test of the overall assessment as the dependent variable. This analysis aims to understand how two different types of teaching methods influence the effect of high school students' learning.

Results

To examine the effectiveness of IWB integrated teaching and classical ICT integrated teaching in teaching biology in secondary schools, the statistical processing of the results was made with ANCOVA to analyze the data.

Effectiveness of the two different types of teaching methods

To understand the impact on the learning effect of two different types of teaching methods in secondary schools (TTM - types of teaching method), this study compares the effects of students' learning from IWB group and T-group using ANCOVA. TTM is taken as the

independent variable, the results of the pre-test of the overall evaluation are taken as the covariate, and the results of the post-test of the overall evaluation are taken as the dependent variable. BeforeANCOVA, the homogeneity of variance assumption was tested. The Levene's test forequality of variances was not significant ($F = 1.279$, $p > 0.05$). In addition, the assumption ofhomogeneity of regression coefficients was also tested ($F = 1.279$, $p > 0.05$). The resultsindicate that neither homogeneity assumption was violated. The results of the ANCOVAanalysis are shown in Table 2.

Table 2 shows that the pre-test scores have a significant influence on the post-test scores ($F=10.694$, $p<0.01$). Further, the TTM also has a significant influence on the scores of posttest ($F=19.67$, $p<0.01$). The result means that student learning in instructional environmentsusing the two different types of teaching method has significantly different learningeffectiveness. It is found that studentsin the IWB group have significantly better learning effectiveness than those in the T group.

Table1. ANCOVA summary table (n=70)

Sources	SS	df	MS	F	Post test
Pre-test	2975.32	1	2975.32	9.897**	
TTM	4875.142	1	4875.142	19.67	IWT>T
Error	13137.264	48	256.311		
Total	179922.001	45			
Corrected total					

**p<.01
TTM – Two different types of teaching
IWB: Interactive Whiteboard group
T: Traditional ICT – integrated group

Conclusion

The topic "Cell division - Mitosis and Meiosis" has always been one of the most difficult topics for learning and teaching for both students and teachers. This fact is confirmed by studies made by Brown, 1995 and Oztap et al., 2003. They argue that the application of certain teaching methods is one of the reasons for the difficulties of students in learning the topic of cell division.To assist students in learning Brown proposes the dynamic nature of cell division that should be emphasized and that the teachers need to properly utilize 2D and 3D images enable

students to make a model of a chromosome. The results of this study show that, compared with classical ICT - integrated teaching, IWB is more effective in the teaching and learning of cell division.

Of all the sub-topics of cell division, IWB is especially effective in helping students to learn the "Role of mitosis" and "Meiosis and sexual life cycle." Classical ICT integrated teaching can only improve effective learning of the subtopic "Chromosome and its importance." This may be the case because, in comparison with classical ICT integrated teaching, IWB can better consolidate multimodal representations, including key concepts such as genes, chromosomes and genetic information.Students can consequently develop more coherent conceptual framework to serve as the basis of their learning of cell division. This can eliminate the difficulties in learning caused by basic concepts - cell nucleus, gene and genetic information, and the relationships between them that are implied separately in different teaching topics (Lewis, 2000b).

The interactive nature of IWB improves the interaction between teacher and students and peers. The teaching of the two subtopics "Role of mitosis" and "Meiosis and sexual life cycle" this study attempts to make interactive nature of closely integrated IWB in teaching activities.Students work together to complete tasks for answering questions about the processes of the two types of cell division and considering the difference between mitosis and meiosis compared with chromosome duplication, the number of divisions, the number of daughter cells and genetic composition. This may explain why students have better learning effectiveness.According to several researchers (Levy, 2002; Torf and Tirotta 2010; Wall, Higgins and Smith, 2005), students think that when they are allowed to use the IWB, their learning can be significantly improved and that their learning process can be better facilitated.In classical ICT integrated teaching, the interaction between teacher and students is limited to verbal communication and messages are communicated through the PPT slides in a more linear way. In comparison, IWB can better integrate multimedia presentations. This may be the reason why students have lower effective learning when traditional ICT-integrated teaching is applied.

Based on the research findings, this study argues that teaching methods are the reason why cell division is considered a difficult topic to study in high school, according to Brown (1995) and Lewis (2000b). Oztap (2003) showed that students lacked a coherent conceptual working framework and often felt confused about genetic terminology. If the relationship between the basic structures such as cell nucleus, chromosomes and genes can be clearly

presented and students can assist in making models of chromosomes, they will be able to overcome difficulties in learning.If the relationship between the basic structures such as cell nucleus, chromosomes and genes can be clearly presented and students can assist in making models of chromosomes, they will be able to overcome difficulties in learning. Brown (1995) also stated that during the teaching activities, both 2D and 3D images can provide students assistance in making models of chromosomes.According to Brown, this study suggests that during teaching activities, teachers can try to integrate multimedia into learning about "Chromosome and its importance." For example, images of colored cells under a microscope can be used for demonstrating the relationship between the cell nucleus and chromosomes, 2D and 3D images can be used to show the structure of the chromosome, and dynamic videos or animations can be used to present chromatin in a eukaryotic chromosome.After students get a clearer picture (understanding) of the basic genetic concepts and the development of a more coherent developmental framework, they will find an easier way to learn more about cell division.

Currently, classical ICT integrated teaching always uses Microsoft PowerPoint slides (PPT slides) to enrich teaching and to break the monotony of the lesson. While PPT slides allow teachers to integrate multimedia presentations, they do not support Adobe-Flash animations - basic interactive media. They can be presented only in a linear manner or page after page when used in educational activities, which makes them educational opportunities more limited.However, this study integrates IWB in teaching. IWB can integrate both multimedia and Adobe-Flash animations - basic interactive media presentation to help teachers perform multimedia or multimodal teaching. The differences between the two types of cell division can be clearly displayed, allowing better understanding. A key feature of IWB - high interactivity allows teachers to have more contact and interaction with students, in addition to verbal communication.It is also easier for teachers to make facilitating interactive teaching and cooperation between students. Teachers and students feel closer to each other, as claimed by Wood (2002), and students are more motivated to concentrate and participate in educational activities (Homles 2009, Northcote, 2010). These advantages greatly outweigh the limitations of PPT slides in teaching and students learn effectively.Based on the findings of this study, the construction of a chromosome model is vital in teaching cell division. The dynamic process of cell division and the micro-view of chromosome changes are also crucial to overcome the

difficulties in understanding cell division. If ICT, multimedia and multimodal presentations are properly used, student learning will be more effective when they learn about cell division.

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