Abstract:

As advancements in gene testing, genetic therapy and cloning become more common, scientifically literate citizens may be expected to have a greater understanding of inheritance. A study performed in England and Wales suggests that misconceptions students have concerning the relationship between genes, chromosomes, and the cell contribute to their misunderstanding of inheritance, (Lewis, 2000). To have an accurate understanding of inheritance, it is necessary to understand cell division. In the following study, the effectiveness of the use of dynamic and static models when teaching cell division was assessed in two sample size classes averaging 20 students. Responses to predetermined questions on a pre and post assessment, journal responses, a mitosis lab, a cell cycle modeling activity and a quiz were used to compare the effectiveness of static vs. dynamic models when teaching cell division. The pre and post assessment and journal responses were used to check for understanding of the purpose of cell division. The mitosis lab, cell cycle modeling activity, and quiz were used to assess their understanding of cellular processes that take place during cell division. Students exposed to dynamic models scored higher on assessments that checked for understanding of the purpose of cell division, and students exposed to static models performed higher on assessments that check for understanding of cellular processes that take place. These results may indicate that static modeling is more effective in learning the process of cell division because students are able to spend time observing details of the stages within the process. Dynamic modeling may be more effective for students to observe the process in its entirety, but may be too fast for students to see details and allowing them to explain the process.
Background:

The purpose of this study was to determine the effectiveness of the use of dynamic models (computer simulations/animations) and static models when teaching cell division. In a study performed in 2001, by the National Center for Education Statistics, it has been determined that 90% of 5-17 year olds use computers and 57% use the internet (DeBell, 2003). Because computers and the internet has become such an integral part of students’ lives, I have wondered if there is a correlation between the use of dynamic models vs. static models and student understanding. According to research done by Oztap, students’ misconceptions of cell division may be contributed to misunderstanding of vocabulary and cell structure. This research also suggests that models and pictorial materials can help students overcome their misunderstandings and lead to a greater understanding of cell division, (Oztap, 2003). A technology review entitled “Simulating Science” by Smetana and Bell states that computer simulations are proven to be more effective than traditional instructional practices when used appropriately (Smetana & Bell, 2006). An article entitled “Molecular and Cellular Biology Animations: Development and Impact on Student Learning” by McClean & Johnson states dynamic simulations are more effective than static simulations because motion leads to greater long term memory retention. According to the article, student learning research shows that visual perception is the most developed sense in humans and is the most important way that students learn (Sekular & Blake, 1985). It further states that animation coupled with lecture is more effective than lectures alone. According to Howard Gardner’s theory of Multiple Intelligence, there are “Eight Different Potential Pathways to Learning”, (Armstrong, 2000). Gardner’s model would state that using static and dynamic modeling
as the primary source to teach cell division only targets the spatial pathway. Therefore, dynamic and static models may not be beneficial for students who learn better through one of the other pathways.

The three factors leading to the development of my research question are the suggestions made by Oztap, Smetana and McClean, statistics concerning student use of computers, and my understanding of designing lessons that address all learning modalities according to brain based research. The population of students being studied includes two science classes of 12-13 year old 7th graders. All of the students attend William Allen Middle School in Moorestown, NJ. Moorestown is a suburban district. The town was named the number 1 place to live by Money Magazine in 2005. The high school into which the school district feeds has been awarded The Blue Ribbon School of Excellence for four consecutive years. Of the population of students being studied, 100% have and use computers and the internet at home. Fifty eight percent of the students spend 2-3 hours each day using the computer.

The following table (A) shows a comparison of student within the two classes being studied.

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Period 4</th>
<th>Period 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of students</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>Number of male students</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Number of female students</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Number in Enriched Language Arts</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Number in Accelerated Language Arts</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Number in On Level Language Arts</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Number in Basic Language Arts</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
It has been observed that the class average and class performance is greater in period 4 than in period 7. Factors contributing to greater student performance by period four include:

- differences in class period times
- the number of students needing extra support in language arts and math
- lunch recess time: period 7 students are coming from recess which may contribute to their high energy level upon entering class

The following table (B) shows a comparison of the learning modalities between students in periods 4 and 7. Students were asked if they felt more confident when learning through visuals, hands-on activities, reading, or listening. The data below was recorded based on student responses.

Table B:
Comparing Learning Modalities of Students in Period 4 and Period 7

<table>
<thead>
<tr>
<th>Learning Modality</th>
<th>Period 4</th>
<th>Period 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Tactile</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Reading</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Auditory</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

The findings from this study will help me understand how to use dynamic and/or static models to plan meaningful lessons which provide students with a deep understanding of cell division. It will also allow students to have a thorough
understanding of cell division and prepare them for genetics by giving them a firm foundation.

**Literature Review:**

**What makes teaching cell division difficult?**

Some difficulties in teaching cell division that were identified in my classroom include unfamiliarity with vocabulary, misunderstanding of chromosomes vs. genetic information and the relationship between DNA, chromosomes, and chromatids. In the past, this lack of understanding contributed to misconceptions about genes.

Difficulties teachers have in teaching cell division are presented in articles by Oztap and Lewis. Forty percent of teachers that were surveyed believe cell division is more difficult to teach than photosynthesis, respiration, genetics, and living systems. Student difficulties are suspected to be due to vocabulary, unfamiliarity with cell structures, teacher confusion, poor understanding of mitosis vs. meiosis, and misunderstanding of chromosomes vs. genetic information. A study was performed in England focusing on assessing student understanding of genes, chromosomes, and the cell. This study was motivated by genetic advancements produced by the Human Genome Project. According to the study, misconceptions students have about the relationship between genes, chromosomes, and the cell, contributed to their misunderstanding of inheritance.

*Teaching Cell Division to Secondary School Students: An Investigation of Difficulties Experienced by Turkish Teachers*

*Haydar Oztap, Esra Ozay, and Fulya Oztap*
Can animations enhance student learning?

Of the four different learning styles (visual, tactile, auditory, and reading) that were presented to the students, 67% in period 7 identified visual learning as their primary modality, and 32% identified visual learning as their primary modality in period 4. As statements concerning student preferences of dynamic vs. static models were evaluated, some students expressed that they preferred dynamic because motion helps them to follow the process of cell division because it could be seen.

Dynamic and static computer animations are being used to enhance college level student learning of cell biology. Student learning research shows that visual perception is the most developed senses in humans and is the most important way that students learn. (Sekular and Blake, 1985). It also makes complex processes become simplified and produces greater long term memory retention. Motion leads to longer term memory, an effect not observed with static images (Goldstein et al, 1982). Animation coupled with lectures is more effective than lecture alone. (Paivio, 1979, 1991) Howard Gardner’s theory of Multiple Intelligences suggests that when possible, design lessons that target more than one of the eight pathways to produce greater student understanding. (Armstrong, 2000).

A study was performed among medical students to compare the effectiveness of computer simulations to visualize complex processes such as DNA replication. The experimental group was given computer simulations to assist in their understanding of the
process and was more successful than the control group which was not given computer simulations.

Molecular and Cellular Biology Animations: Development and Impact on Student Learning
*P. McClean et. Al*

Perception
*R. Sekular & R. Blake*

Imagery & Verbal Processes
*A. Paivio*

Recognition Memory for Pictures: Dynamic vs. Static Stimuli
*A. Goldstein*

Multiple Intelligences
*T. Armstrong*

**Should teachers include inquiry when using computer simulations?**

Computer animations have been successful to allow students to learn science concepts, however using animations is not 100% effective. Computer animations need to allow students the opportunity to learn through inquiry to change their beliefs about science concepts. Cognitive process combined with dynamic modeling is believed to produce the greatest perceptual change (S.C. Li et al., 2006)

In the article written by Smetana, it was stated that computer simulations in science are proven to be more effective than traditional practices. Traditional practices include the usage of hands on labs and activities. Although computer simulations are more effective, they must be used as a supplement, not a substitute. Guidelines when using simulations include:

- Using them in addition to what has already been used
• Providing alternate representations of the topic leading to a greater understanding
• Ensuring that simulations support meaningful learning
• Maintaining student centered and inquiry based lessons
• Keeping the focus on the content not the technology
• Emphasizing to students that the simulations are models

Technology News
Lara K. Smetana
Randy L. Bell

Cognitive Perturbation Through Dynamic Modelling: A Pedagogical Approach to Conceptual Change in Science
S.C. Li, N. Law, K.F.A. Lui

Are animations equally as effective?

A comment made by some students when they were asked if they preferred dynamic vs. static models to learn cell division was static because “animations went too fast, but I could keep looking at the pictures in the binder.” Another student responded by saying, “I can look at the pictures longer; the animations only lasted about 3 seconds.”

Static graphics must be carefully designed to convey complex systems. It is suggested that dynamic graphics may be better than static models when showing change over time. When comparing effectiveness of static vs. animated graphs, animated include more information and interactivity. However, animations may be too complex or too fast to be accurately perceived. Animations are ore effective if they have an interactive component, which allows the user to stop, pause, or repeat the program.
Do all students spend equal time using computers?

Of the students being studied, 100% of them have a computer with internet access at home. Computer and internet use among U.S. children 5-17 years old was studied. The report compared computer and internet use among inner city and suburban children, students of various ages, races/ethnicities and students with various family incomes. It was concluded that computer and internet usage is greatest among children living outside of the city, white children, children in two parent homes, and children with high family incomes. There was not a difference between male and females.

Computer and Internet Use by Children and Adolescents in 2001
National Center for Education Statistics

Methodology:

Recruitment Procedure:

Teacher informs students in each period about a comparative study in which they will be given the opportunity to participate. The teacher tells the students that the next topic that they are responsible for learning will be human heredity. To understand heredity, they must have a clear understanding of cell division. The teacher encourages student participation and stimulates interest by briefly stating the relationship of cell division to forms of skin cancer due to sun bathing. The topic of sun bathing will stimulate student interest because it is predicted that the majority of
students in each of the five classes participate in sun bathing as an extracurricular activity.

**Obtaining Informed Consent**

After informing students about the purpose of the study (to compare the effectiveness of dynamic vs. static models to teach cell division) the teacher will distribute the parental consent forms given by The University of Pennsylvania MISE-program. The teacher will emphasize the voluntary nature of the study and the choice to withdraw from the study as stated in the consent form. The teacher will discuss each part of the consent form and students will be given 3 bonus points for getting parental consent. All students proving that the consent form was presented to a parent/guardian will receive three bonus points. Permission to be able to participate in the study must be evident by the signed consent form.

**Participate Privacy**

All information will be kept under the care of the instructor. Neither the student(s), nor other teachers will have access to research evidence. Only the teacher giving the study and participants in the MISE-program will have necessary access to student information.

**Instruments/Design:**

Procedures and Experimental Design

1. Students will complete the attached demographics survey.
2. Before introducing cell division, the students will complete the attached cell division pre-assessment (which will be identical to the post-assessment).

3. Teacher will collect:
   a. pipe cleaners which will be used by students to demonstrated the stages of mitosis
   b. posters and transparencies showing the stages of the cell cycle
   c. animation sites on cell division (included)
   d. onion cell cycle lab (attached)

**Use of Surveys/Questionnaires**

1. The demographics survey will be used to determine if there is a difference in understanding of the content based on variables such as gender, math level, or language arts level.

2. The cell division pre-assessment will be given to check for students’ base knowledge.

**Procedures: Static Models for Pd. 4; Dynamic Models for Pd. 7**

**Day 1**

1. Students will complete the cell division pre-assessment.

2. Teacher will introduce sexual vs. asexual reproduction
   - sexual reproduction: 2 parents produce genetically different offspring
     (example: Meiosis in egg and sperm cells)
   - asexual reproduction: one parent produces genetically identical offspring
     a. budding in yeast cells: teacher will mix yeast, warm water, and sugar in a test tube. Teacher will use a pipette to remove some of the activated yeast cells from the test tube and make a wet
Williams, Classroom Based Research Project

mount. Methylene blue will be used to observe the unicellular yeast cells. Teacher will show students the budding cells on the microscope. (Both periods)

b. Binary fission in bacteria: teacher will draw a picture on the board to show how bacteria reproduce asexually by binary fission. (Pd. 4) Teacher will share an example of how they may have experienced reproducing bacteria when they have gotten a progressively sore throat due to a bacterial infection.

(Pd. 7 will see an animation on cellsalive.com)

c. Mitosis in plant and animal cells: teacher will only introduce mitosis by telling students that it is a form of reproduction in plant and animal cells to produce new cells and repair old or damaged cells.

Day 2.

1. Students will describe the structure of a chromosome.
   - Teacher will define the chromosome as a structure that carries the genetic information controlling traits such as eye color and blood type.
   - Ask students if all organisms contain the same number of chromosomes. Ask students how many chromosomes humans have. Be sure that students are aware that humans have 46 chromosomes. Tell them that all organisms do not have the same number of chromosomes, for example:
     - Ameba have 50
     - Carrots have 18
     - Cats have 32
Dogs have 78
Earthworms have 36
Goldfish have 94

Ask students what all the numbers have in common. (They are all even numbers because each of these organisms reproduces sexually. They receive half of the chromosomes from each “parent”)

(pd. 7 will see a brief video clip on chromosomes via safarimontage)

3. Teacher will show an illustration of the structure of a chromosome with the sister chromatids and the centromere labeled. (pd. 4) Be sure that students understand that DNA is located inside of the chromosomes. Emphasize to students that the sister chromatids that make up a chromosome contain identically DNA.

4. Briefly introduce the stages of the cell cycle (give cell cycle notes)
   - Interphase- cell prepares for division
   - Mitosis- cell’s nucleus divides
   - Cytokinesis- the parent cell splits to form two daughter cells

5. Tell students to answer the following question in their journal:
   Who has more cells, you or a one month infant? How do you know? (Collect a small sample of answers)

Day 3
1. Students will illustrate the stages of mitosis
2. Teacher will tell students to turn to the cell cycle notes that were distributed the day before. Teacher will also give detailed notes on the stages of the cell cycle.
3. Teacher will describe each stage of the cell cycle using illustrations, drawings, transparencies, and posters (pd. 4). (pd. 7 cells.alive.com

http://www.pbs.org/wgbh/nova/baby/divi_flash.html


4. Teacher and students will describe the stages of the cell cycle in words.

5. Teacher will demonstrate hand movements to represent the stages of mitosis.

6. Journal question: Give a type of cell in your body that you think is short lived. Explain.

Day 4

1. Students will use pipe cleaners to represent the stages of mitosis.

2. Teacher will revisit posters and transparencies of the cell cycle (pd. 4) (pd. 7 will revisit the websites).

3. Teacher will give students an even number of pipe cleaners to represent the number of chromosomes in an imaginary organism.

4. Teacher will call out various stages of the mitosis and students must use the pipe cleaners to show how chromosomes move to specific positions in the cell during mitosis.

5. Journal question: Why do some cells live longer than others?

Day 5

1. Students will calculate the length of the cell cycle in an onion root tip.

2. See the attached lab for a detailed procedure.
Day 6

1. Students will complete their cell cycle post-assessment which is identical to the pre-assessment.

2. The use of static and dynamic animations will be reversed within the classes.

Day 7

Students will assess their understanding of the cell cycle. (Cell Cycle Quiz)

A. Data Analysis:

For Days 2-7:

Compare student journal responses of the dynamic model study and the static model study. Find the average of correct answers in each class. Determine if there is a correlation between the average of correct answers in each class and the model undergoing study. Determine if there is a correlation between the time spent on the computer and the preference of static or dynamic modeling.

Day 1- Average of correct answers on pre-assessment

Day 2- Compare journal responses

Day 3- Compare journal response of the dynamic model study and the static model study.

Day 4- Compare journal response and mitosis illustrations using pipe cleaners

Day 5- Compare lab grades

Day 6- Compare improvement on cell cycle pre-assessment to cell cycle post-assessment

Day 7- Compare quiz results
D. Time Schedule: See Procedures

Student Demographics Survey

Name: ________________________________

Gender: circle Male or Female

What is your current math level? __________________________

What is your current language arts level? ________________________

Do you learn more through visuals, hands-on activities, reading, or listening? ________________________

Do you have a computer at home? _____________ If so, do you use it? ________________________

If you have a home computer, does it have internet access? _____________ If so, do you use it? ________________________

If you have a home computer, how much time do you spend on it?

a. less than 1 hr  b. 2-3 hrs  c. 4-5 hrs  d. 6 or more hrs
CELL DIVISION PRE-ASSESSMENT

DIRECTIONS: ANSWER EACH OF THE FOLLOWING QUESTIONS ON CELL DIVISION TO THE BEST OF YOUR ABILITY. I AM AWARE THAT YOU MAY HAVE LITTLE TO NO UNDERSTANDING OF CELL DIVISION, BUT DO YOUR Best TO ANSWSER EACH QUESTION. PLEASE ANSWER EACH QUESTION IN COMPLETE SENTENCES AND BE SURE TO USE DETAIL.

1. How do you grow?
2. Why are cells small?
3. How many cells do you think you are made up of? Are they all the same?
   (explain)
4. Do your cells die? If so, how do you know and give an example of when they died.
5. How does your body make new cells? What would happen if new cells were not made?
6. Do other organisms make new cells? How do you know?
7. Can your cells be repaired? Explain why or why not?
8. Do all of your cells contain DNA? If so, does each cell have the same DNA? Explain your reasoning.

****On the copy given to the students, they will be given space to answer each of the questions.
Cell Cycle in an Onion Cell

Problem: What is the longest stage of the cell cycle in an onion cell?

Hypothesis:

Procedure:
1. Place your slide on the microscope stage.
2. Use low power to locate the bottom of the onion root tip.
3. Switch to high power.
4. Beginning in the column to your left, add a tally mark in the data table below to indicate the stage of the cell cycle for about 35 cells. (Be sure to place your tally marks in the correct column.)

<table>
<thead>
<tr>
<th>Stages of Cell Cycle</th>
<th>Bottom of slide</th>
<th>Middle of slide</th>
<th>Top of slide</th>
<th>Total Number</th>
<th>Time in stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interphase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitosis: prophase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitosis: metaphase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitosis: anaphase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitosis: telophase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total number of cells counted __________
5. Repeat steps 2-4, but for the middle and the top of the onion root tip.
6. Fill in the column labeled Total Number by adding the numbers across each row in your data table.
7. Add the total numbers for the five stages **to find the total numbers** of cells counted. Record this value on the line next to “total number of cells counted.”

**Results:**

1. What stage of the cell cycle did you observe most often? 
   
2. The cell cycle for onion root tips takes about 720 minutes (12 hours). Use your data and the formula below to find the number of minutes each stage takes. Record your results in the data table.

   \[
   \text{Time for each stage} = \frac{\text{Total Number (of cells in stage)}}{\text{Total number of cells counted}} \times 720 \text{ minutes}
   \]

3. Was your hypothesis correct? Why or why not?
4. Use your data to make a bar graph comparing the times that the cells spend in interphase, prophase, metaphase, anaphase, and telophase. You must use graph paper.
Name                                      Period
Date                                        Cell Cycle Quiz

Directions: Read each question and fill in the correct answer. (1 pt. each)

1. When would you find two nuclei in a cell? ________________________

2. When do sister chromatids separate? ______________________________

3. When do the centriole’s spindle move chromosomes to the middle of the cell? __________________

4. During which phase of mitosis does chromatin change to chromosomes?

5. During which phase of mitosis do chromosomes become shorter and thicker (condense)? __________________

6. During which stage of the cell cycle does DNA replication occur?

7. What is the longest stage of the cell cycle? ___________________

8. List the 3 stages of the cell cycle in order.

9. How many chromatids make up a chromosome? ______________

10. If an organism has 100 chromosomes, how many chromatids would the organism have during metaphase? __________________

**Be sure to complete the back**

*** On the back of the quiz, there were illustrations of cell stages. Students were responsible for identifying the cell stages. (8 pts.)
FINDINGS:

Cell division assessment results from periods 4 and 7 were compared. The model that was used to teach cell division prior to giving the post assessment in period 4 was static models. Dynamic models were used to teach cell division prior to giving the post assessment in period 7. In addition to comparing pre and post assessment tests, students’ content knowledge was assessed by completing a mitosis lab, cell cycle quiz, mitosis modeling activity, and journal questions. The following tables compare student computer use, student preferences of dynamic or static models, and the students’ assessment results.

Table C
Comparing Times that Students Spend Each Night on the Computer

<table>
<thead>
<tr>
<th>Time</th>
<th>Period 4 (n=22)</th>
<th>Period 7 (n=21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) less than 1 hour</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>(b) 2-3 hours</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>(c) 4-5 hours</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>(d) 6 or more hours</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

* The total number of hours spent on the computer is greater for period 7.

Table D
Comparing Student Preferences of the Use of Dynamic vs. Static Modeling to Learn Cell Division

<table>
<thead>
<tr>
<th>Model</th>
<th>Period 4</th>
<th>Period 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Static</td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>

* The total number of hours spent on the computer according to Table C is greater in period 7. The majority of the students in period 7 prefer to learn cell division through dynamic models. Less overall time is spent on the computer in period 4 and their preferred method of learning cell division is through the use of static models.
Table E
Comparing Student Responses to the Use of Dynamic Models

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Period 4</th>
<th>Period 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>You can see changes, movement, processes, you know what the chromosomes are doing</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>It’s more fun</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>You get a visual in your mind</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* Of the fourteen students in period 7 who preferred dynamic models, 10 give the same reasons. Of the four students in period 4 who preferred dynamic models, 2 give the same reasons as the 10 students in period 7

Table F
Comparing Student Responses to the Use of Static Models

<table>
<thead>
<tr>
<th>Student Responses</th>
<th>Period 4</th>
<th>Period 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier to remember pictures</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Animations are too fast</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Pictures make it easier to observe, explain, and/or remember</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

* The majority of students in period 4 preferred to learn cell division through static models. Eight of the 16 students in Table F state the same reason for choosing static models. Of the 7 students in period 7 who chose static models, 4 stated the same reason as the 8 students from period 4.

The results from Tables C-F may suggest that there is a correlation between the time spent on the computer, student preferences of dynamic or static modeling, and students’ learning modalities. In period 7, more total hours were devoted to computer time each night, which indicates a higher level of interest, they preferred dynamic over static
Williams, Classroom Based Research Project

modeling, and they identified themselves as visual learners. The students in period 4 spent less total time on the computer each night, preferred static models over dynamic models, and most identified themselves as tactile learners. It was also noticed that students preferred the initial model that was used to learn cell division. The initial model used for period 4 was static simulations which are what they preferred. The initial model for period 7 was dynamic, which is what they preferred. The following tables show a comparison between the assessment results.

**Table G**

Comparing the Assessment Results of Period 4 and Period 7

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Period 4</th>
<th>Period 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-assessment (8 possible pts.)</td>
<td>4.54</td>
<td>4.09</td>
</tr>
<tr>
<td>Number of correct journal responses</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>Mitosis lab (35 possible pts.)</td>
<td>33</td>
<td>31.7</td>
</tr>
<tr>
<td>Cell cycle quiz average (18 possible points)</td>
<td>15.4</td>
<td>14.7</td>
</tr>
<tr>
<td>Post assessment (8 possible pts.)</td>
<td>6.26</td>
<td>6.4</td>
</tr>
<tr>
<td>Pre to post assessment Point improvement</td>
<td>1.72</td>
<td>2.11</td>
</tr>
<tr>
<td>“Total Score”</td>
<td>82.92</td>
<td>90</td>
</tr>
</tbody>
</table>

Of the assessments in Table G, the pre and post assessment and journal responses were used to check for understanding of the purpose of cell division. The mitosis lab, cell cycle modeling activity, and quiz were used to assess their understanding of cellular processes that take place during cell division. Students exposed to dynamic models scored higher on assessments that checked for understanding of the purpose of cell division, and students exposed to static models performed higher on assessments that
check for understanding of cellular processes that take place. These results may indicate that static modeling is more effective in learning the process of cell division because students are able to spend time observing details of the stages within the process. Dynamic modeling may be more effective for students to observe the process in its entirety, but may be too fast for students to see details and allowing them to explain the process. This idea is supported by student responses in tables E and F.
The results from this study lack consistency, therefore it can not be determined if dynamic or simulated models are more effective to teach cell division. Although the total point value suggests that period 7 made the most improvement, factors such as modified assignments and additional time that are given to students in period 7 may have influenced the total point score. Also, the data indicates that period 7 did not perform better than period 4 on the cell quiz or the mitosis lab. If dynamic models were as beneficial as period 7 students claimed, period 7 should have scored higher on those assessments. Period 7 should have demonstrated greater performance because the questions required an understanding of the movement of chromosomes. If there was a greater difference in the total point score between periods 4 and 7, the results may have been more conclusive.

In both periods 4 and 7, there were three misconceptions that were commonly stated among the students on their pre and post assessment. Many believed that the body “holds” cells. On the pre and post assessment, when students were asked “How do you grow”, answers such as “you grow because you cells are dividing and you need more space to store them” indicates that some of the students do not understand and/or believe that all living things are made up of cells.

The second frequently stated misconception was that different cells within an organism contain different DNA because all cells do not have the same function. From this misconception, it can be concluded that students do not understand the purpose of DNA replication and the inheritance of chromosomes.

Results from the pipe cleaner model differed between periods 4 and 7. When the students were told to use the pipe cleaners to show how the chromosomes would be
arranged in the cell during metaphase of the cell cycle, the most frequent responses from periods 4 and 7 are shown below.

The incorrect response, given by most students in period 4 may have been due to their misconceptions of:

- Preparation of chromosomes to result in 2 cells with identical DNA; when asking why students arranged their chromosomes in the manner listed above, many replied, “Does it matter? There are lined up in the middle of the cell”
- lack of understanding of chromosome vs. sister chromatids
- disbelief in the uniqueness of each chromosome
- cytoplasm will split in between the chromatids

The correct response given by most students in period 7 may be contributed to their ability to recall the movement of the chromosomes in the dynamic simulation.

Two less frequent responses were to the question, “do all of your cells have the same DNA” Many students responded by stating “DNA comes from the father and mother, so each cell has different DNA.” Their misconception could be due to:
• misunderstanding that 23 chromosomes are from each parent, resulting in body cells with 46 chromosomes
• meiosis has not yet been covered; students are unaware that some cells have only 23 chromosomes which are a combination of each parent's chromosomes
• students don’t know that segments of DNA are responsible for controlling each cell's function, but the same DNA is in each cell

Students who answered this question correctly, in periods 4 and 7, stated that they know DNA copies itself and DNA is from mom and dad, so each cell must have all of the DNA from each parent.

**CONCLUSION:**

In a medical school, a study was performed on students learning the complex process of DNA replication. The experimental group was given computer simulations to assist in their learning and the control group was not. The results indicated that computer simulations, whether dynamic or static, cause greater understanding of complex processes than learning without computer simulations. The nature of many computer animations is to provide images and animations through direct instruction. The teacher must continue to allow students to learn through inquiry (S. Li et al, 2006). A combination of cognitive and dynamic modeling produces the greatest perceptual change. Tversky & Morrison suggest that dynamic modeling is more effective than static when showing changes over time, but teachers must be aware that for students to accurately perceive complex processes, an interactive component may be necessary.
As previously stated, misconceptions concerning cell division were:

1. The body holds cells
2. Different cells within an organism contain different DNA because all cells do not have the same function.
3. Arrangement of chromosomes during metaphase
4. Each cell has different DNA because DNA comes from the father and mother

In the future, to prevent these misconceptions, I will couple animation with lecture (Paivio, 1979, 1991). This can be accomplished by using these misconceptions to formulate questions to give to students before and between the use of dynamic simulations.

Sample questions that focus directly on misconceptions:

1. A student is using pipe cleaners to model the arrangement of chromosomes during metaphase of mitosis. This is the conclusion that the student reached (use the same drawing from Figure 1)

   Explain why you agree or disagree with the students representation of the arrangement of chromosomes during metaphase of mitosis.

2. Explain why you agree or disagree with the following statement:

   We grow because we are making more and more cells. Our body must then grow so that the cells can fit inside of our body. Why do you agree or disagree?

3. Explain why you agree or disagree with the following statement:

   We have proof that DNA in each of our cells is different because each of our cells has a different function.
4. Do you agree or disagree with the following statement.

Some of our cells have our mother’s DNA, whereas others have DNA from our fathers. But, we can never have DNA from each parent in the same cell.

Since I have learned that there are different learning styles and no one has only one style, it was my former belief that students would be more successful in their understanding of the cell cycle if dynamic models were used. To produce effective lessons that allow students to understand the process of cell division and the purpose of cell division, I would encourage the use of dynamic and static models. Although Sukarlar & Blake’s state that student learning shows visual perception is the most important way that students learn, the results from this study indicate that both are needed to provide a more comprehensive understanding of cell division (Sukular & Blake, 1985). To prevent the confusion that many students felt as they viewed dynamic models of cell division, I will pause the animations and include static models. Pausing to include static models will allow students to have the time that they need to process information and see the cellular processes in specific stages. Pausing will also allow me to teach through inquiry by allowing students to make predictions about cell processes.
Resources


.