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EFFECT OF DIAGNOSTIC REMEDIAL TEACHING PROGRAMME ON CONCEPT UNDERSTANDING IN CELL BIOLOGY

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Abstract

Some foundational Concepts in Cell Biology continue to cause cognitive conflict among students and cause learning difficulties among them. Investigations into students' understanding in Cell Biology concepts indicate that students of varying ages possess misconceptions in Cell Biology. To promote effective and meaningful learning, there is a need to identify the causes of such misconceptions and find ways to rectify them or prevent them from occurring. The present study was undertaken to identify the students' misconceptions in Cell Biology through the Two - Tier Diagnostic test. The sample comprised of 191 students' of class IX selected from secondary schools of Phagwara city. On the basis of this test 14 students' misconceptions were identified in the various sub-concepts of Cell Biology.

Keywords: *Cell biology, Misconceptions, Two – tier Diagnostic Test*

Introduction

A major thrust in science education research over the past three decades has been the documentation of students' misconceptions in a wide range of subject areas (Pfundt & Duit, 2004). The term "misconceptions" has been coined to describe alternative conceptions or views of science which are not consistent with concepts currently accepted by the community of

scientists. Misconceptions are part of a larger knowledge system that involves many interrelated concepts that students use to make sense of their experiences. Students hold misconceptions that were developed before and during their early school years. These misconceptions may be compounded by the teacher or the textbook (Bahar, 2003 & Wandersee et al, 1994). A large number of studies reported that primary and secondary school students have many conceptional problems concerning Cell Biology and genetics (Flores et al., 2003; Lewis & Wood-Robinson, 2000; Marbach-Ad & Stavy, 2000). Prior studies have shown that students experience difficulties in learning concepts related to the cell division process (Kindfield, 1994). Cell division constitutes the basis for genetics, reproduction, growth, development, and molecular biology subjects in the biology curriculum. As a matter of fact, a majority of the students or teachers evaluated topics such as gene, DNA, chromosome, and cell division as difficult to learn topics (Oztas et al., 2003).Many studies have been reporting students various misconceptions about Cell Biology (Yilmaz et al, 1998; Lewis et al, 2000; Clark & Mathis, 2000; Atilboz, 2004; Kruger et al, 2006; Saka et al, 2006; Gropengieber, 2008). Cell Biology is one of the most important areas in Biology and understanding the structure and functioning of Cells is basic to all Molecular and Genome level Biology studies. There is an important new role for Cell Biology at the Secondary School level, and it relates to Biotechnology and the enhancement of human well-being. To completely Figure out these developments basics of Cell Biology must be clear to the students and our future citizens. Understanding the basic Concepts of Cell Biology is essential for the efficient scientific literacy of citizens in the modern world (Venville et al., 2005).Therefore effective teaching strategies should be introduced in the curriculum so that students can make correct scientific connections among various concepts in Cell Biology.

Aims And Objectives

The aim of this study was to identify the common misconceptions of students in concepts of Cell Biology and to evaluate the current understanding of Cell Biology among senior secondary students. The investigator developed a Two-tier Diagnostic Test in Cell Biology to evaluate students' misconceptions.

Methods And Procedures

Sample

The sample consists of 191 students of class IX selected from secondary schools of Phagwara city. Diagnostic Test in Cell Biology (DTCB) was developed and standardized at the tryout stage

involving 92 class IX students. At the field stage, 99 students were drawn from three secondary schools of Phagwara and its suburbs of Punjab State. The participants belonged to Class IX students, who have already studied the topics in their classrooms. The samples used at Try out and Field Stages were different but belonged to the same population.

Development Of Two-Tier Multiple Choice Diagnostic Test

In this study, Diagnostic Test in Cell Biology (DTCB) was developed by the researcher which contains 27 items to determine students understanding of Cell Biology concepts. These items were selected from the different subtopics in Cell Biology. The design of the Two-tier Diagnostic Test instrument was based on a process described by Treagust (1995). In the Two-tier multiple choice diagnostic test, the first tier of each test item consisted of a content question asking students to predict the outcome of a situation and provided several distracters along with the correct answer. The second part asked for a reason for the answer the student gave in the first part. The reasons from which students choose include the correct answer and possible misconceptions identified in research literature. The instrument was developed in three stages. Stage 1 involved defining the content area of the study. Stage 2 involved identifying students' misconceptions in cell biology. Stage 3 involved the development of two tier diagnostic instrument.

Stage 1- Defining the content area of the study

The major sub-concepts included in this study were Cell Theory, Cell Division and Cell Transportation:

- Cell Theory (different types of cells, structure and size, plant cell & animal cell)
- Cell Organization (different cell organelles, mitosis & meiosis)
- Cell Transportation (Osmosis & Diffusion)

The Concept of Cell and its Organelles were part of the syllabus of class IX students and they are expected to be familiar with these Concepts. The Concepts were defined using twenty Propositional Knowledge Statements (PKS), which were covered in the Two-tier items of the Diagnostic Test.

Stage 2 – Identifying students' misconceptions from the research literature

Cellular Structure and Organization are the fundamental Concepts in Biology Education, but, many students in the class experience difficulties for explaining the relationships between the Cell, Nucleus, Chromosome, and Gene Concepts, and the similarities and differences between

Mitosis and Meiosis (Lewis & Wood-Robinson, 2000). Clark and Mathis (2000) had found the students often have misconceptions in Cell Division, Chromatids and homologous pairing of chromosomes. Kruger el al (2006) had studied misconceptions on Cell Division and growth. Saka et al (2006) investigated the misconceptions about concept of Gene and Chromosomes among science student teachers and found that these concepts were not clear to the future teachers. Some of the most widely studied misconceptions in Cell Biology relate to the Concepts of Cell Division and Diffusion & Osmosis (Odom & Barrow, 1995; Zuckerman, 1998). Inadequate understanding of Osmosis and Diffusion has been documented among high school and college students (She, 2004).

Research has shown that students have difficulty in making the connection between Molecular and Cellular Organization (Driver et al., 1994). A large number of prior studies reported that primary and secondary school students have many conceptual problems concerning Cell Biology and Genetics (Clark & Mathis, 2000; Fisher, Lewis & Wood-Robinson, 2000; Williams, & Lineback, 2011). Conclusion from all these studies depicted a clear picture that the student misconceptions research from the 1990s and beyond has provided valuable insights into student thinking by revealing the underlying conceptual sense of student errors. Authors have compiled various misconceptions in Cell Biology in the Table 1, which have been identified from research literature.

Table 1: Misconceptions identified from research literature

1.	Cells of living organisms do not make molecules for their own growth and repair.
2.	As the size of a multicellular organism increases, the size of the cells increases rather than there being more cells that accounts for the increase in size.
3.	Certain parts of the body of multicellular organisms are not made of cells.
4.	Cells are as small as atoms.
5.	Cells do not carry out essential life functions for the organism they are part of.
6.	All cells are of same size and shape
7.	Interior part of cell is filled with solid.
8.	Animal cells do not eliminate their own wastes.
9.	Plant cells do not extract energy from food.
10.	Animal cells do not make molecules for their own growth.
11.	Plant cells do not carry out essential life functions for themselves.
12.	A gene and the expression of the gene as a characteristic or trait are the same thing.
13.	The information in the DNA molecules of an organism does not affect the functions of an organism's cells.
14.	Two types of nucleotides make up DNA molecules.
15.	Each DNA molecule is made of more than one chromosome.
16.	Chromosomes do not contain genetic/hereditary information.

17. Both haploid and diploid cells can divide by mitosis to produce two daughter cells with the same chromosome component as the parent cell.
18. Osmosis and diffusion are fundamentally different processes.
19. As the difference in Concentration increases between two areas, rate of Diffusion increases because the molecules want to spread out.
20. As the difference in Concentration increases between two areas, rate of Diffusion decreases because if the Concentration is high enough, the particles will spread less and the rate will be slowed.
21. Water molecules cease movement at osmotic equilibrium.

The distracters in the Two-tier Diagnostic Items were based on student conceptions that were identified from the Related Research Literature and shown in Table 1.

Stage 3 – Development of the two-tier multiple-choice diagnostic instrument

The diagnostic instrument developed in this study was composed of 27 two-tier multiple-choice items. The first draft of 32 items was refined after item analysis. After two successive trials on 92 students, the final version of the instrument, the *Diagnostic Test in Cell Biology (DTCB)* consisting of 27 items was developed incorporating 21 student conceptions that were identified in stage 2 of the study. In deciding on the final 27 items, consideration was given to items that elicited a wide range of responses, apart from ensuring that all the sub concepts were adequately included in the instrument. In the two-tier multiple choice diagnostic test, the first tier of each test item consisted of a content question asking students to predict the outcome of a situation and provided several distracters along with the correct answer. The second part asked for a reason for the answer the student gave in the first part. The reasons from which students choose include the correct answer and possible misconceptions identified in research literature. Example of a Two-tier diagnostic item in the DTCB is given in Figure 1.

Figure 3: Sample Item of Two-Tier Multiple Choice Diagnostic Instrument

Item No. 29 (Cell Transport---Osmosis and Diffusion)
As the difference in Concentration between two areas increases, the rate of Diffusion:

A. Decreases B. Increases C. Remains the same

The reason for my answer is

1. There is less room for the particles to move.
2. If the Concentration is high enough, the particles will spread less and the rate will be slowed.
3. The Molecules want to spread out.
4. The greater likelihood of random motion into other regions.

Correct Answer: B2
Misconceptions Addressed

- As the difference in Concentration increases between two areas, rate of Diffusion increases because the molecules want to spread out.
- As the difference in Concentration increases between two areas, rate of Diffusion decreases because if the Concentration is high enough, the particles will spread less and the rate will be slowed.

The responses of 92 students to the 27 items in the DTCBwere analyzed using a SPSS statistics software program. The answer to an item was considered to be correct if both content and reason parts were correctly answered. The reliability of the instrument was established by a Cronbach alpha coefficient of 0.73 for the 92 cases and 27 items. This value is acceptable as it is greater than the threshold value of 0.5 for multiple-choice items quoted by Nunally (1978). The validity of the FMGDI was also accessed by a panel of experts who judged that it measured concepts (rather than factual knowledge).

Results And Discussions

DTCB instrument was administered to 99 students at the field stage. Students' responses were analyzed for any possible misconceptions. A respondent's answer to an item was considered correct if he/she selected both the correct content and reason option. Items of the instrument were evaluated for both the correct responses combination selected by the respondents. The students answer were analyzed and revealed that out of 21 misconceptions incorporated in DTCB, 14 were held at least by 10% of class IX students. The concept of Cell Biology was already taught in classroom, but students still had difficulties in understanding various concepts. The 14 students' misconceptions identified by DTCB and the percentage of students who held these misconceptions are summarized in table 2.

Table 2: Misconceptions identified by DTCB

Students' Misconceptions	**Percentage of Students with identified misconceptions**
Living organisms are made up of few cells.	17.08%
As the size of a multicellular organism increases, the size of the cells increases rather than there being more cells that accounts for the increase in size.	27.02%
Cells of living organisms do not make molecules for their own growth and repair.	11.02%
Interior part of cell is filled with solid.	16.95%
Cells do not carry out essential life functions for the organism they are part of.	12.71%
Cells are as small as atoms.	16.95%
Animal cells do not eliminate their own wastes.	22.03%

There are some types of organisms that do not have DNA.	14.41%
Both haploid and diploid cells can divide by mitosis to produce two daughter cells with the same chromosome component as the parent cell.	10.17%
DNA is a type of protein.	11.86%
As the difference in Concentration increases between two areas, rate of Diffusion increases because the molecules want to spread out.	18.56%
As the difference in Concentration increases between two areas, rate of Diffusion decreases because if the Concentration is high enough, the particles will spread less and the rate will be slowed.	35.45%
Osmosis and diffusion are fundamentally different processes.	31.02%
The rate of osmosis is constant and does not vary with a difference in solute concentrations between two solutions separated by a selectively permeable membrane.	18.64%

Cell Theory: The most common misconceptions were identified in cell theory was those animal cells don't eliminate their own wastes with 22.03% of students having the misconception. These students' seems to lack an understanding about the removal of waste products by the animal cells. This is the highest percentage of misconception identified. Hence the teachers should remove these misconceptions by using suitable teaching strategies.

Cell Organization: Cell organization is the most effective part in cell biology because here the students are often gets confused between the various cell organelles and the role of mitosis and meiosis in cell division. Most of the students were not able to distinguish between the genes, chromosomes and DNA exactly. This might occur due to the traditional method adopted by the teachers while teaching or due to overburden syllabus which they might have to finish till the end of the session.

Cell Transportation: The misconceptions relating to cell transportation illustrate that the students in the sample were confused about the simple process of Diffusion and Osmosis. According to them both the processes are same because it involves the movement of particles. Hence a lot of students got confused between these two processes.

Conclusion

The results of the study provide evidence to indicate that, despite the fact that cell biology is the major part in the curriculum of secondary schools; despite of it still the sample of students at higher level is facing the problem of misconceptions. This is all due to the poor understanding about various concepts in cell biology. The two tier diagnostic instrument in cell biology provides a feasible approach for identifying students' misconceptions of the topic. The study

reports 14 misconceptions in cell biology. Secondary school teachers and university academics can use this information to develop effective instructional strategies so as to remove the misconceptions from the minds of students. Similarly, the curriculum department of the Ministry of Education can get benefits from these findings to review the current instructional materials to ensure that the concepts are taught at a level consistent with the students' prior knowledge and cognitive abilities. Further an important work should be done in the formation of different instructional strategies and classroom teaching that will assist teachers and students to overcome misconceptions in future.

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