Combining different conceptual change methods within 5E model: A sample teaching design of 'cell' concept and its organelles

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Abstract

Since students' misconceptions are not completely remedied by means of only one conceptual change method, the authors assume that using different conceptual methods embedded within the 5E model will not only be more effective in enhancing students' conceptual understanding, but also may eliminate all students' misconceptions. The aim of this study is to display a sample teaching of the cell and its organelles by combining different conceptual change methods (analogy, conceptual change text and worksheet) within the 5E model. But, the study has a shortcoming in seeking the degree to which conceptual change is achieved. For this reason, further research should focus on applicability of the presented teaching design in a comparative manner.

Keywords: Misconceptions, conceptual change methods, constructivism

Introduction

Since biology is a conceptual science, students may find biological concepts difficult. Therefore, students tend to memorize the biological concepts rather than using conceptual learning techniques (e.g. Özcan, 2000). That is, if students are unable to link the new knowledge with their pre-existing knowledge, (s)he prefers procedural learning (e.g. Kahveci & Ay, 2008). Despite the fact that student's pre-existing idea is very crucial for further learning, an unstructured (or structured inaccurately) idea may generate an obstacle to achieve conceptual learning. Such incorrect views are generally named *misconceptions*, different from those accepted by scientific community. The misconceptions held by students are also pieces of intellectual thought in case of concepts (e.g. Çalık & Ayas, 2005; Yağbasan & Gülçiçek, 2003). Why misconceptions arise can be explained by several factors: *student's insufficient prior knowledge, his/her bias, his/her deficiency of motivation, teacher's insufficient content knowledge, paying more attention to details instead of concepts, textbooks including misconceptions, using daily life language instead of scientific one and cultural factors*. – meaning that some concepts may lead different meanings in various cultures (Aşçı et al., 2001; Goh et al., 1993; Storey, 1991; Harrison et al., 1999; Lubben et al., 1999).

Since students' pre-existing conceptions are very significant for further learning, the subsequent perspectives have commonly been studied: *structural and functional features of the "cell"* (e.g. Doğru 2001; Kama, 2003; Marek, 1986), *osmosis and diffusion* (e.g. Atılboz, 2004; Marek et al., 1994; Odom & Barrow, 1995; Tarakçı et al., 1999; Westbrook & Marek, 1991), *photosynthesis* (e.g. Çapa, 2000; Köse, 2004), *genetics* (e.g. Lawson & Thompson, 1988; Lewis & Kattman, 2004; Özcan, 2000; Özdemir, 2005), *ecology* (e.g. Özkan, 2001), *respiration* (e.g. Sander, 1993; Akpınar, 2007), *cell metabolism* (e.g. Storey, 1991; Westbrook & Marek, 1992), *cell division* (e.g. Doğru, 2001, Baggot & Wright, 1996; Kindfield, 1994; Lewis &

Wood-Rabinson, 2000; Yılmaz, 1998;) *and physiological systems* (e.g. Sungur, 2000; Teixeira, 2001; Tunnicliffe & Reiss, 1999). Of these perspectives, the cell and its organelles play a significant role in explaining many phenomena taking place in our bodies (e.g. Doğru, 2000; Kama, 2003; Marek, 1986). Further, they are the cornerstone for further learning such topics as *genetics, reproduction, evolution, developing and growing and biotechnology*.

When the first author noticed that most of science student teachers enrolled in 'Biology Laboratory' had misconceptions of the concept of the cell and its organelles, the authors looked for related literature to constitute a theoretical framework. Four misconceptions the first author determined are cited in the related references: (a) students place chloroplast to all plant cells (e.g. Kama, 2003) (b) many students believe that centrioles are responsible for cell division (e.g. Kama, 2003) (c) students draw oval or round shapes to illustrate the 'cell' (e.g. Clément, 2007; Flores, 2003), (4) the nucleus is always in the center of the cell (the fried-egg model) (e.g. Clément, 2007). The misconception that the 'pore is viewed as a gap in cell wall' has not been elicited previously. Widodo et al. (2002) stated that there is a gap between teacher's theoretical knowledge and their practical classroom constructivist behavior; therefore, the authors attempt to present a sample teaching activity in order to inform the science and biology teachers on how to incorporate students' misconceptions in their courses. A Turkish idiom illustrates the authors' position *'if everybody clears up his or her home front, there is no need to use a street sweeper'!*

In brief, few studies have focused on the structure of cell and its organelles. The related studies have generally listed the misconceptions held by the students rather than producing alternative ways to remedy them. Generally, to accomplish conceptual change conceptual change text, analogy/model, worksheet, concept maps, etc. are used. But Chambers and Andre (1997) emphasized that first hand experience is more effective than conceptual change texts. Although using analogical reasoning or modeling is efficient in teaching science, most teachers do not use them as often as might be expected and tend to neglect their advantages (Harrison 1998; Treagust et al., 1998). Even if they attempt to exploit analogies/models, this frequently occurs in an unplanned manner (Duit, 1991; Nottis & McFarland 2001; Thiele & Treagust 1995). Also, the related literature stresses that using the only one conceptual change method may be boring to students, thereby; this may prevent to achieve effective results (Dole 2000; Huddle et al. 2000; Türk & Çalık, 2008).

Since students' misconceptions are not remedied completely by means of the only one conceptual change method, the authors assume that using different conceptual methods embedded within 5E model will not only be more effective in enhancing students' conceptual understanding but also may eliminate all students' misconceptions. The aim of this study is to display a sample teaching of the cell concept and its organelles by combining different conceptual change methods (analogy, conceptual change text and worksheet) within the 5E model.

Theoretical Framework

Now we will firstly outline 5E model.

Table 1. The content of 5E model (adapted from Bybee et al., 2006)

Phase	Explanation
Engagement/Enter	Teacher identifies the students' prior knowledge and gets them to engage in a new concept by means of short activities or questions promoting curiosity and increasing their awareness of pre-existing knowledge.
Exploration	Teacher encourages the students to work in their small groups and asks probing questions to redirect the students' investigations by refraining from any clue. In this phase, students acquire new knowledge by linking it with prior one
Explanation	This phase provides an opportunity for the teacher to directly introduce the new concept, process or skill. Hence, the teacher confirms/disconfirms students' gained knowledge claims. That is, the students compare their newly structured ideas with those presented by the teacher
Elaboration	The teacher fosters the students to apply their understanding of the concept and skills to additional activities, thereby; they attempt to extend their newly structured knowledge to deeper and broader understanding, more information, and adequate skills.
Evaluation	This phase not only promotes students to assess their understanding and abilities but also gives an opportunity for the teacher to monitor how students' understandings have progressed

Teaching Design

Now we will illustrate our developed teaching design.

Engagement/Enter

Before handing out the worksheet, students are divided into small groups of 3-4 students. To activate students' pre-existing knowledge, the following question at the top of the worksheet (Appendix 1) is asked: "Are there any differences between animal and plant cells?" By doing this, students become conscious of their peers' pre-existing ideas.

Exploration

Since the worksheet is handed out, students are asked to conduct the related activities in their small groups by following the given directions in the worksheet (Appendix 1). The teacher also asks probing questions to redirect the students' investigations, if necessary, by refraining from any clue. After completing the activities, students are asked to respond the following questions: '*Assume that your generated models illustrate animal and plant cells, which of them is an animal cell? Which of them is a plant cell? Please defend your response', 'In your generated models, please match your used materials with cell organelles by marking the type of cell with signal (X)', 'Since you tracked the same steps for both of the plates (steps 1-9), why did you follow the last three steps (10-12) for the only one plate? Please explain your reason', 'Could you compare the position of nucleus in the animal cell with that of the plant one? Please defend your response' and 'Taking into account the foregoing schema, please address the different organelles between the animal and plant cells'*

Explanation Phase

Since each group completed the activities, they present their structured knowledge claims and share their ideas with their peers through a class discussion. Then, the teacher confirms/disconfirms students' gained knowledge claims, so that the students compare their newly structured ideas with those presented by the teacher. Further, a transparent paper with plant and animal cells is represented (Figure 1). The teachers also stresses that various prototypes of 'cell' such as *yeast cells, protozoa, nervous cells and so forth* exist.

Elaboration Phase

Using conceptual changing text (Appendix 2), the teacher fosters the students to elaborate their understanding of the concept 'cell' and its organelles to deeper and broader understanding and more information. This phase enables students to have an attempt to increase their conceptual understanding and to eliminate their misconceptions within multiple learning styles (e.g. Brinda, 2004; Harvey & Hodges, 1999).

Evaluation Phase

To reinforce students' newly constructed conceptions, the following question is used: '*Please compare the factory with the structure of 'cell' in terms of their structural or functional features and then fill in the gaps'*. To evaluate students' conceptual understanding, the teacher can also exploit the concept map (see Figure 2) by removing some concepts and interrelationships. Further, to make students become conscious of their learning, they are asked to outline what they have learned.

Implications for Practice

To teach the concept of the cell and its organelles, an alternative teaching method is represented here. But, the study has a shortcoming in seeking the degree to which conceptual change is achieved. For this reason, further research should focus on applicability of the presented teaching design in a comparative manner. Since materials presented here are simple, actual and economic, using hand-on activities should be paid more attention.

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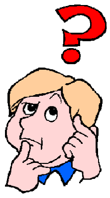
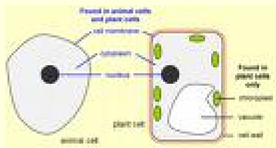
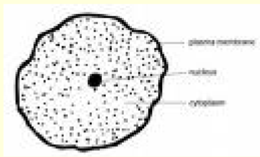
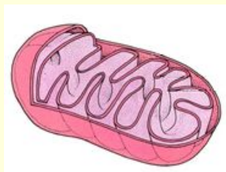
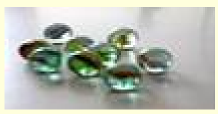
Appendix –1: Worksheet

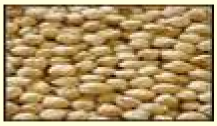
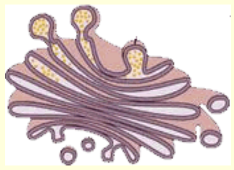
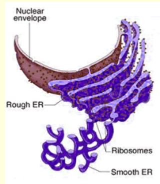
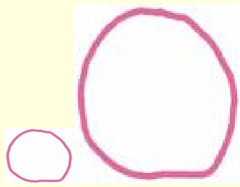
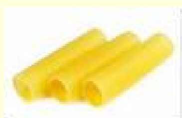
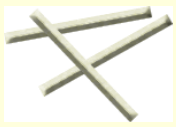
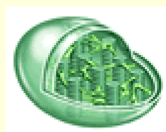
Are there any differences between animal and plant cells?



Materials: Angular plate   Oval plate   Play dough
Ping-pong ball   Nylon fiber   Clothes line

If you follow the directions, you are able to answer the above questions.

	Direction	Concrete Material	Organelle
1	Distribute ‘play dough’ into both angular and oval plates.	 	
2	Surround each of plates with nylon fiber and embed spaced composition nylon fiber within the play dough with your pencil.		
3	Place each of grains of haricot bean into each of plates randomly		
4	Place each of marbles into each of plates randomly.		

5	Place each of chickpeas into each of plates randomly.		
6	Compose zigzag constructions with two layers by using wide rubber, and place them to each of the plates randomly.		
7	Compose two zigzag constructions by using round rubber, and place them to each of the plates randomly (they must be ranged from ping-pong ball to nylon fiber).		
8	Place randomly six 5 cent coins into the oval plate, and three 1 Turkish Lira coins into the angular plate.		
9	Surround the angular plate with a clothesline, and embed the spaced composition clothes line within the play dough using your finger.		
10	Spread the glue on two tube macaronis, and then place them into the oval plate.		
11	Place the French bean into the angular plate.		

12	Locate one of the ping-pong balls to the center of the oval plate while placing the other to edge of the angular plate.		

(Images were retrieved July 10, 2008 from *http://images.google.com.tr/images*)

Q1: Assume that your generated models illustrate animal and plant cell, which of them is an animal cell? Which of them is a plant cell? Please defend your response.

………..

Q2: In your generated models, please match your used materials with cell organelles by marking the type of cell with signal (X)

Material	**Organelle' name**	**Animal cell**	**Plant cell**
Angular plate			
Oval plate			
Play dough			
Ping-pong ball			
Nylon fiber			
Haricot bean			
Marble			
Chickpea			
Wide rubber			
Round rubber			
5 Cent Coin			
1 Turkish Lira Coin			
Clothes line			
Tube macaronis			
French bean			

Q3: Since you tracked the same steps for both of the plates (steps 1-9), why did you follow the last three steps (10-12) for the only one plate? Please explain your reason.

……………………………………………………………………………………………

Q4: Could you compare the position of the nucleus in the animal cell with that of the plant one? Please defend your response.

……………………………………………………………………………………………

Q5: Taking into account the foregoing schema, please address the different organelles between the animal and plant cells.

……………………………………………………………………………………………..

Based on your gained experiences, please answer the following question

Q6: Please compare the factory with the structure of 'cell' in terms of their structural or functional features and then fill in the gaps.

Analog Feature	**Comparison**	**Target Feature**
Factory	Compared to	Cell
Administration and control centre of factory	Compared to	…………………….
…………………..	Compared to	Cytoplasm
Uploading and downloading department	Compared to	………………..
Power station of factory	Compared to	…………………..
…………………………….	Compared to	Lysosome
Manufacturing center of factory	Compared to	…………………
Packaging department of factory	Compared to	……………….
……………………………..	Compared to	Vacuole
Conveyor belt system of factory	Compared to	……………………..
…………………………..	Compared to	Cell Wall
Energy and storage centre of factory	Compared to	………………
…………………….	Compared to	Centrioles

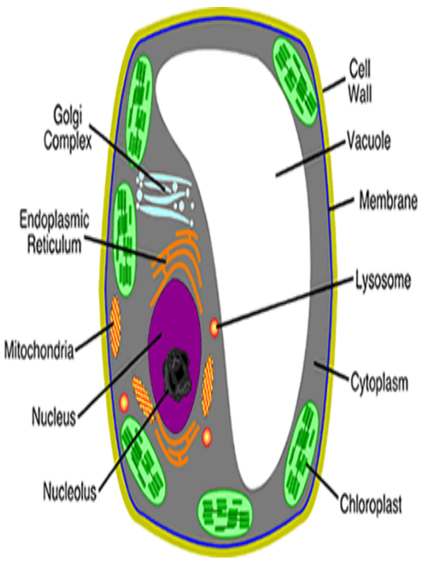
Appendix–2: Conceptual Change Text

Are there any differences between animal and plant cells?

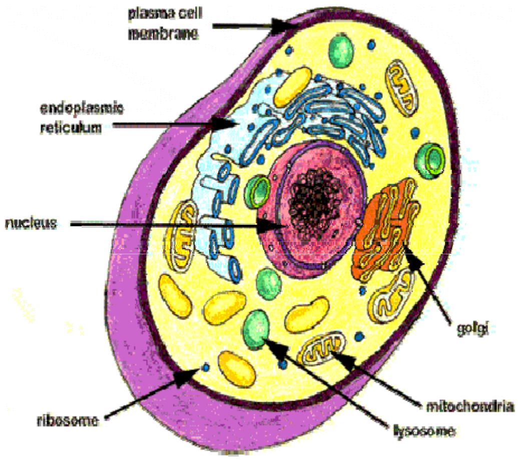
Some of the students' misconceptions are:

- Students draw oval shapes to illustrate the 'cell'.
- Nucleus is always in the center of the cell.
- Students place chloroplast to all plant cells.
- "Pore" is viewed as a gap in cell wall.
- Centrioles are responsible for cell division.

Some students merely draw oval or round shapes to illustrate the 'cell'. However, the structure of the 'cell' has different shapes. For example, animal cell is oval/circular shape whilst plant cell is an angular one. A few students consider that nucleus is always in the center of the cell. However, this is wrong because nucleus is on the edge of plant cell due to size of vacuoles. Some students placed chloroplast to all plant cells. But this is not very common. The chloroplast, which is a kind of plastid, may not exist in the plant cell. Further, since plastids (chloroplast, leucoplast and chromoplast) are called in regard to its reflecting light spectrum, a transformation amongst them may occur. Some students view the pore as a gap in the cell wall. However, this is wrong because the pore is a constituent of the cell membrane and not available on the cell wall. Gaps on the cell wall afford the nutrition transition. A few students think that centrioles are not only responsible for cell division but also move the spindle fibers to poles of the cell. Although there is no centriole in the plant cell, the cell division appears in the plant cell. Therefore, the centrioles do not take for the cell division directly.



PLANT CELL



ANIMAL CELL

Figure 1. A transparent paper with plant and animal cell (Retrieved January 17, 2008 from http://www.biologycorner.com/bio1/cell.html)

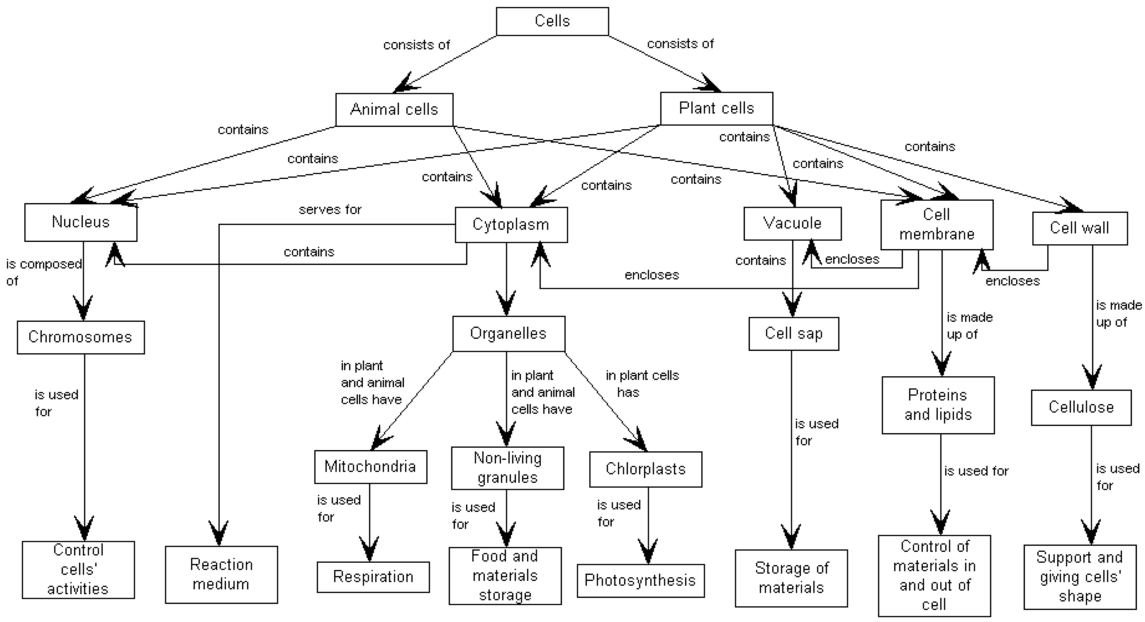


Figure 2. Concept map (Retrieved January 17, 2008 from http://www.fed.cuhk.edu.hk/~johnson/misconceptions/concept_map/cellstr.html)