

Chapter 2

Utilizing Concept Cartoons to Diagnose and Remediate Misconceptions Related to Photosynthesis Among Primary School Students

Chong Li Yong and Ch'ng Zhee Kee

Keywords Concept Cartoons • Misconceptions about photosynthesis • Primary school students • Primary science curriculum

2.1 Introduction

Photosynthesis is an important science concept that is included in the curriculum of many countries. It is repeatedly taught at different age levels. Due to the importance and the difficulty of the subject, students have various misunderstandings and hence have developed misconceptions about photosynthesis. Currently, in the Malaysian Primary Science Curriculum (KSSR for Years 1, 2 and 3; KBSR for Years 4, 5 and 6), photosynthesis is one of the main topics. The concept of photosynthesis is taught in the topic of Basic Needs of Plants in the Year 4 Science Curriculum as add-on knowledge that pupils need to know. In the learning outcomes of the Year 5 topic of Food Chains, in which “pupils need to identify the producers in the food chain”, the concept of photosynthesis emerges again in order to let the pupils know why the plants are classified as producers. Often pupils have misconceptions that teachers do not realize. The reasons behind these misconceptions include the instructional methods used, parents, textbooks, the curriculum, teachers’ perceptions and even the children’s experience. This has to be remedied before entering secondary school where students will be learning about photosynthesis in more detail.

L.Y. Chong
Jit Sin (A) Primary School, Bukit Mertajam, Penang, Malaysia

Z.K. Ch'ng (✉)
Keow Kuang Primary School, Bukit Mertajam, Penang, Malaysia
e-mail: zheekee@gmail.com

The use of *Concept Cartoons* is one of the strategies among the range of constructivist pedagogical strategies that are used. *Concept Cartoons* were introduced in 1991 by Stuart Naylor and Brenda Keogh. These were initially used as a strategy to elicit learners' ideas, to challenge their ideas and to provide insights into how these ideas are developed (Keogh and Naylor 1999). *Concept Cartoons* as teaching and learning materials are often used by researchers (Chin and Teou 2009; Dündar and Şentürk 2012; Ingec 2008; Kabapinar 2005; Keogh and Naylor 1999, 1996; Keogh et al. 2002; Sexton 2010). Previous studies suggest that *Concept Cartoons* are effective in diagnosing and remedying the misconceptions related to photosynthesis, besides promoting motivation and participation in learning science (Chin and Teou 2009).

2.2 Background

2.2.1 *Misconceptions Related to Photosynthesis*

Students' incorrect patterns of responses, informal ideas, non-scientific interpretations and conceptions leading to conflict with scientific views are referred to by different terms such as “preconceptions”, “misconceptions”, “alternative frameworks” or “alternative conceptions”. For the purpose of this study, the term “misconception” will be used throughout. Misconceptions are stable cognitive structures that affect learners' understanding of scientific concepts, and these are highly resistant to change (Taşlıdere 2013).

Parents, folklore, teachers, multimedia and even learners themselves are responsible for cultivating these misconceptions. Faulty information from textbooks and science curricula are also responsible for perpetuating misconceptions. Despite many efforts to correct misconceptions, students continue to build their own explanations of science phenomena (Gooding and Metz 2011). To overcome misconceptions, the NRC (1997) suggests that teachers must first identify these misconceptions, provide a forum for students to confront them, and then help students to reconstruct and internalize their knowledge, based on scientific models. Misconceptions can be corrected, but the students need to take the initiative to correct the misconceptions. A misunderstood concept must be realized by the learners and finally recognized as a discrepancy. So, the teachers ought to provide students with opportunities for conceptual change through various activities (Gooding and Metz 2011).

Examination of the literature shows that students have a large number of misconceptions about photosynthesis (Köse 2008; Tlala et al. 2014; Yenilmez and Tekkaya 2003). Studies have been conducted on the food source of plants, definition of photosynthesis, respirations in plants, flow of energy during photosynthesis and the main products of photosynthesis. Studies related to photosynthesis focus mainly on two areas: food sources of plants and the definition of

Table 2.1 Several misconceptions about the food sources of plants and definition of photosynthesis held by students

Food sources of plants	Definition of photosynthesis
Carbon dioxide, water, sunlight chlorophyll	Plants convert water and carbon dioxide into oxygen by means of photosynthesis
Minerals	Plants convert sunlight into food by means of photosynthesis
Soil	Carbon dioxide and chlorophyll are produced at the end of photosynthesis
Nitrogen and fertilizers	Photosynthesis involves the process of food production by plants utilizing oxygen
Vitamins	Photosynthesis is the process of food production of plants utilizing carbon dioxide
Plants do not need any food	Only green plants undergo photosynthesis

photosynthesis. Table 2.1 summarizes several misconceptions held by students about the food sources of plants and the definition of photosynthesis.

2.2.2 Teaching Using Concept Cartoons

Concept Cartoons were developed in an effort to highlight the relationship between the constructivist approach and classroom applications (Keogh and Naylor 1999). According to Driver et al. (1994), in constructivism, learners actively construct their own understanding and knowledge of the world, through experiencing things and reflecting on these experiences. They construct new opinions by relating them with old knowledge (Dündar and Sentürk 2012). Besides that, the constructivist approach also requires the environments for individuals to socially interact to facilitate meaningful and enduring learning (Ekici et al. 2007).

In this case, the *Concept Cartoons*, targeting active involvement of students, provide them with a social environment to express their ideas freely, especially in science and technology courses (Saka et al. 2006). In other words, *Concept Cartoons* provide a constructivist learning environment where the students are able to participate in classroom discussions comfortably and enjoyably (Ekici et al. 2007). During class or group discussions, the students will have the opportunity to compare their original ideas with the ones in the cartoons. They will also have opportunities to listen to their peers’ explanations about the correct science concept and build on their initial conceptual framework. They will have the opportunity to investigate and reinterpret the ideas in the cartoons (Kabapınar 2005). This enables pupils to correct their misconceptions and construct the correct science concepts actively in an interactive environment through *Concept-Cartoon* cartoon-based teaching.

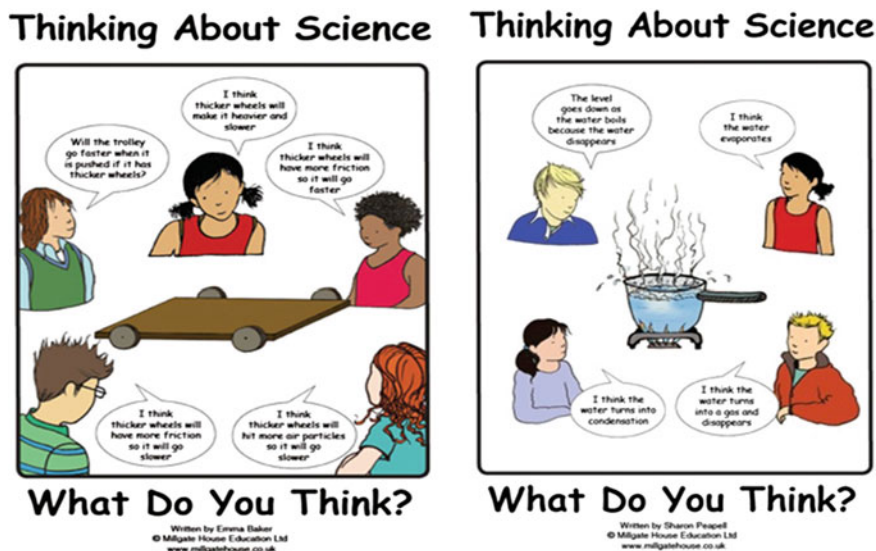


Fig. 2.1 Examples of *Concept Cartoons* obtained from <http://www.millgatehouse.co.uk/>

Unlike comic strips which are designed for humour, *Concept Cartoons* present the students with science concepts. *Concept Cartoons* include a visual representation of a few characters in settings familiar to students along with the use of written language in speech bubbles (Keogh and Naylor 1999; Sexton 2010). In *Concept Cartoons*, several children's concepts, which include the scientifically accepted one regarding a scientific phenomenon, are presented. Two examples are the *Concept Cartoons* on velocity of the wheel board and boiling of water (see Fig. 2.1). After reading the dialogues, the students decide which character's view they agree with without feeling shy about expressing their own opinions. The students may join the debate with the cartoon characters.

According to Naylor and Keogh (2012), *Concept Cartoons* need to have the following features as teaching materials:

- Based on everyday situations that do not appear to be scientific.
- Present alternative viewpoints on the situation, including the scientifically accepted one.
- Have a blank speech bubble, to give a clear statement that there may be more ideas that are not yet included in the dialogue.
- The background text is written in students' language.
- All the alternative viewpoints have equal status by minimizing any contextual clues such as facial expressions or wording of statements.
- The speech bubbles include common misconceptions.
- A minimal text is used.

Generally, the responses to *Concept Cartoons* are very positive and provide an innovative and effective approach to teaching and learning in science. For several years, *Concept Cartoons* have been developed and improved based on feedback from researchers (Keogh and Naylor 1999). As *Concept Cartoons* have become more widely recognized, they have become a focus for research. There are a number of studies that have been carried out on various purposes using *Concept Cartoons* in education: restructuring of ideas (Keogh and Naylor 1996), as assessment tools (Chin and Teou 2009; Ingec 2008; Keogh et al. 2002), eliciting ideas and understanding concepts (Keogh and Naylor 1999; Kabapinar 2005; Sexton 2010), promoting positive attitudes to science teaching and learning (Keogh et al. 2002), promoting investigations, motivation and involvement (Dündar and Şentürk 2012; Kabapinar 2005; Keogh and Naylor 1996), uncovering the reasons behind students' misconceptions, minimizing classroom management problems (Keogh and Naylor 1999) and remedying misconceptions (Kabapinar 2005).

Several benefits have been found in the use of *Concept Cartoons*, including developing language skills, engaging students in higher order thinking skills, creating interactive learning environments, auditing subject knowledge of student teachers, and as effective stimuli for argumentation (Naylor and Keogh 2012). *Concept Cartoons* are generally suitable as teaching materials for all ages of students. However, findings of Kabapinar (2005) suggest that not all *Concept Cartoons* provide a purpose for practical work, only those that possessed concrete, testable phenomena did so. For instance, according to Kabapinar (2005), if the tested phenomenon is on "change of mass on physical and chemical changes", then the *Concept Cartoons* should provide a concrete experience about this issue to the students.

2.3 Objectives and Research Questions

In this study, attempt was made to identify the effectiveness of *Concept Cartoons* in diagnosing and addressing primary students' misconceptions about photosynthesis. This study was guided by the following research questions:

- (1) What is the effectiveness of *Concept Cartoons* in diagnosing primary students' misconceptions related to photosynthesis?
- (2) What is the effectiveness of *Concept Cartoons* in addressing primary students' misconceptions related to photosynthesis?

2.4 Methods

2.4.1 Sample

This study was conducted at a primary school in Penang, Malaysia. The sample consisted of 29 Year 4 pupils who were taught photosynthesis. Male respondents constituted 58.62% (17) of the sample while female respondents constituted 41.38% (12) of the sample. Also, 11 of the respondents were high achievers (37.93%), eight were intermediate learners (27.59%) while 10 were slow learners (34.48%). Students were categorized into three categories of learners (high achievers, intermediate and slow) based on their performance in the previous science test.

2.4.2 Research Design

This study is entirely qualitative in nature. The first stage of the study focuses on teaching the students about the food sources of plants and the definition of photosynthesis. For this purpose, *Concept Cartoons* that would assist the students to identify and address the misconceptions related to food sources of plants and the definition of photosynthesis were used in the teaching and learning process. The *Concept Cartoons* were projected on to the screen so that all the pupils were able to see the *Concept Cartoons* clearly. Then, in-class discussions were carried out. During the class discussions, pupils were asked to choose which character in the *Concept Cartoons* that they were in favour of and explain their reasons for choosing the characters. All the 29 pupils participated in the discussions. The teacher only facilitated the discussions without providing any answers. At the same time, the teacher asked questions that encouraged the students to participate in the learning. This enabled the pupils to listen to their peers' arguments and question their own ideas. Additionally, this also created opportunities for the pupils with the correct concept to help to change the conceptual frameworks of the pupils with misconceptions. Discussions that took place during the intervention were videotaped and analysed.

In the second phase of the study, interviews were carried out with the students who were identified with misconceptions during the in-class discussion sessions. During the interviews, a different set of *Concept Cartoons* was used as a guide and at the same time to encourage them to talk. Pupils' responses were recorded and analysed in order to determine their understanding of the subject of photosynthesis after the intervention. All the *Concept Cartoons* constructed in this research were validated by experienced science teachers. The characters in the *Concept Cartoons* were labelled in an attempt to minimize classroom management problems during the class discussion (Kabapinar 2005). The following questions were asked during the interviews:

1. Do you like the cartoon?
2. What do you feel about the implementation of this subject in this way?
(Follow-up questions: Have you enjoyed it? Was it boring?)
3. What are the food sources of plants?
4. What is photosynthesis?
5. Do you remember the answers that you gave during the discussion?
 - 5a. Do you think that the character you have supported is correct?
 - 5b. When did you realize it?

(The 5th question was only asked to the students who were identified with misconceptions.)

2.5 Results

The data of this study were collected from the researcher's observations during the in-class discussions and interviews that were conducted after the discussions. In the following section, analysis of interview transcripts and recorded in-class discussions will be provided. In order to protect the identity of the students, pseudonyms were used to address them in this study.

2.5.1 *In-Class Discussions*

The teacher acted as a facilitator in the in-class discussions. She encouraged the pupils to voice their opinions. The teacher also guided the discussions in a way that pupils could be aware of the misconceptions and correct the misconceptions by listening to the teacher and their peers. Additionally, peers with correct understanding also helped the others to correct their misconceptions. In the following section, findings obtained from in-class discussions about food sources of plants and the definition of photosynthesis will be provided.

2.5.1.1 In-Class Discussions About the Food Sources of Plants

The *Concept Cartoons* about food sources of plants (1) and (2) (Figs. 2.2 and 2.3) were projected on the screen. The pupils were given some time to look through all the characters before starting the discussion.

After studying the *Concept Cartoons* that were projected on the screen, the whole-group discussions started. The following are the transcripts of the conversations that transpired between the teacher and the pupils during the in-class discussions.

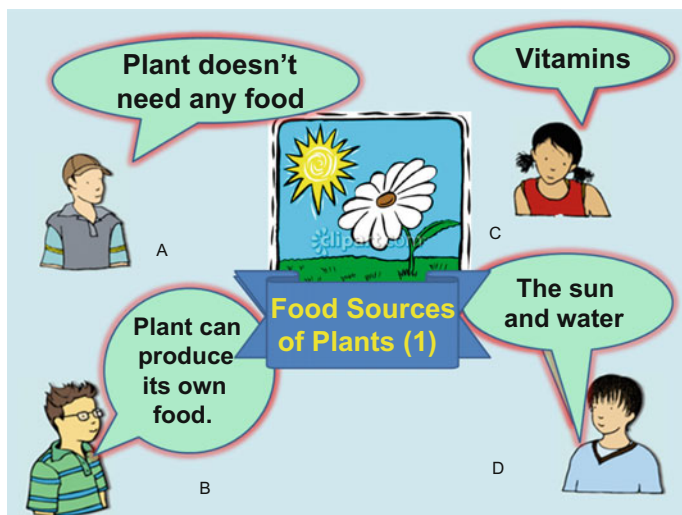


Fig. 2.2 Food sources of plants (1)

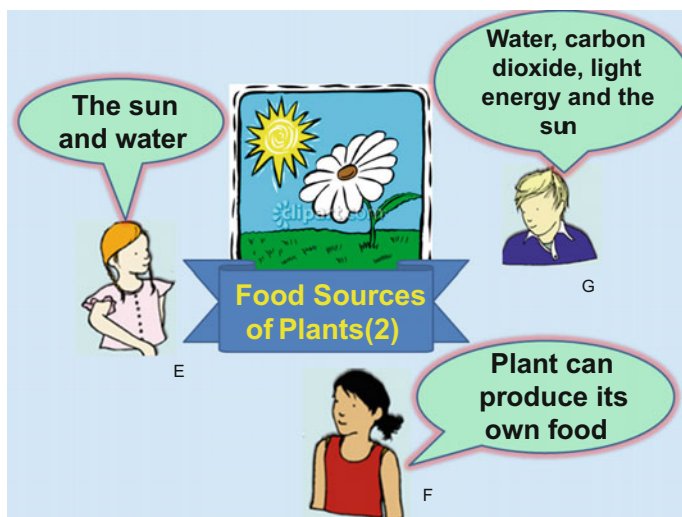


Fig. 2.3 Food sources of plants (2)

(T- Teacher, M: Students with misconceptions; C: Students without misconceptions)

T: What is your answer to the question "What are the food sources of the plants?" Which character do you think is correct?

M2: F. Fertilizers.

T: Why do you think so?

- M2: Because when we add fertilizers to the soil, the plant can grow.
T: But is it the food for the plants?
M: Yes, it is. Because the plant can grow.
T: Do you think it is correct??
M: I think fertilizers are food...hmmmm
T: Who agrees with his answer?
(no response)
T: Who disagrees with his answer?
(Many raise their hands)
T: Why do you think his answer is wrong?
M3: Because fertilizers are not food, they can only make plants grow better.
T: If fertilizers are not food, then what are the foods of the plants?
M3 and M8: (said together) Food is made by plants themselves from sunlight, water and carbon dioxide.
M8: Fertilizers might not be a food.
T: Ok. Then, are sunlight, water and carbon dioxide foods of the plants?
(Many responded with “yes” and “no”)
C1: They are not the food for the plants, but the things the plants need to produce food.
T: Ok. How about the other pupils?
C2: They are simply the things that make plants produce food.
T: Character C said that the food for plants is vitamins. Who thinks that he is correct?
M8: No, same with the previous one. It will make plants grow better but not food.
T: Are vitamins important?
C3: Yes, if they do not have vitamins, they will fall sick.
T: How about soil? (Pointing to Character E) Is soil a food for plants?
C1: No, soil is not a food. They can live without soil.
C4: They can live on cotton pads like green beans that we used to plant. They also can live in water.
M4: So soil is not a food for plants.
T: So, which character do you agree with now?
Pupils: B!!! (Some did not voice their opinions)
T: Who has other answers?
(M5 raised her hand)
M5: Character F.
T: Ok. Try to think again later. M 2, have you changed your mind on the food source of the plants?
M2: Yes.
T: Which character do you agree with now?
M2: B. A plant can produce its own food. Because fertilizers are not food, they only help plants to grow better.

During the in-class discussions, some pupils took part actively while some just followed the discussions by paying attention. After the introduction, the pupils started to voice their opinions about the subject. C1, C2 and C3 were identified as students without misconceptions about food sources of plants. They helped to correct their peers' misconceptions during the discussion without themselves realizing it.

Something interesting was that M8 who stated that sunlight, water and carbon dioxide are the food for plants had actually corrected himself and stated that food is made by plants themselves from sunlight, water and carbon dioxide during the class discussion. He initially wanted to correct M2's idea about fertilizers being the food for the plants. When probed by the teacher by asking what the foods of the plants are if fertilizers are not, he reconsidered his own answer and stated that the plants produced their own food using sunlight, water and carbon dioxide. This shows that he actually understood the concept but with some confusion. He realized that the answer that he gave was incorrect when the same question was asked again.

However, there were still a handful of pupils who still stuck to their misconceptions after the discussion. For example, M5 still stated that water, the sun, light energy and carbon dioxide are the food sources of the plants. This is because the misconceptions may have deeply penetrated into students' minds to (Küçüközer and Kocakulah 2007). As the in-class discussions aided with *Concept Cartoons* was carried out in one lesson only, some pupils still could not change their alternative frameworks. For this kind of pupils, more lessons and discussions aided with *Concept Cartoons* about the same subject should be carried out in order to remedy their misconceptions. Nevertheless, it was observed that most pupils have already overcome their misconceptions about the subject at the end of the in-class discussion.

2.5.1.2 In-Class Discussions About the Definition of Photosynthesis

The *Concept Cartoons* about "What is photosynthesis (1) and (2)?" (Figs. 2.4 and 2.5) were projected on the screen. The pupils were given some time to look through all the characters before starting the discussion.

After studying the *Concept Cartoons* that were projected on the screen, the whole-group discussion started. The following are the transcripts of the conversations that transpired between the teacher and the students during the in-class discussion.

(T- Teacher, M: Students with misconceptions; C: Students without misconceptions)

T: Look at the cartoons. Which character do you agree with about the definition of photosynthesis? Which character do you think has the same thoughts as you?

M2: Character Q.

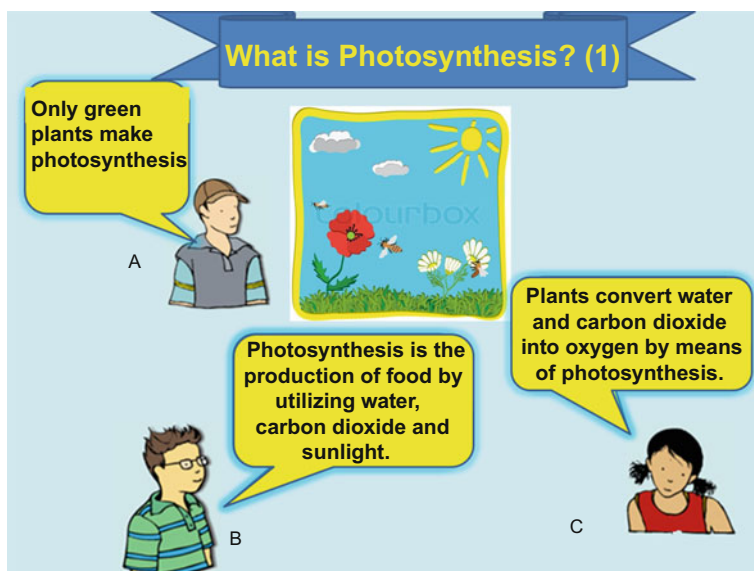


Fig. 2.4 What is photosynthesis? (1)

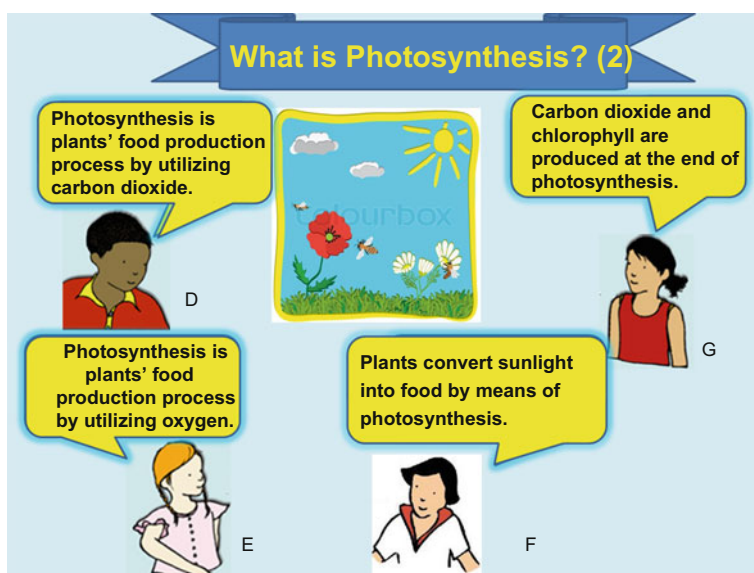


Fig. 2.5 What is photosynthesis? (2)

- T: So you mean that photosynthesis only produced carbon dioxide and chlorophyll?
- M2: Yes.
- T: Who agrees with him?
(No one raised their hands)
- T: Who disagrees with him?
(Many raised their hands)
- C1: Chlorophyll is not produced, but oxygen and food are. Carbon dioxide is needed for photosynthesis.
- T: Ok. What is needed in order for photosynthesis to occur?
- M12: Sunlight?
- M13: Carbon dioxide and water.
- T: Besides sunlight, carbon dioxide and water, are any other things needed?
(They thought for a while)
- C2: Chlorophyll!
- T: Is chlorophyll important?
- C1: Yes, it is important. Without chlorophyll, photosynthesis is unable to be carried out by plants.
- T: Good. If we need chlorophyll, is it only green plants that can carry out photosynthesis?
(Many asked their peers and after a short pause some students nodded)
- T: Who thinks that besides green plants, there are other organisms that can carry out photosynthesis?
- C3: I think so, but I have never seen it. I think they will be other small organisms.
- T: Have you seen algae that live in the water? Is it a plant?
(All nodded)
- T: Have you ever thought they are not plants but considered as simple organisms?
(All silent)
- T: Algae are actually not considered as plants. They are classified as microorganisms which are neither plants nor animals. You will only learn about microorganisms in Year 5. So now, only green plants carry out photosynthesis?
(Some still nodded; some changed their opinion and shook their heads)
- T: Ok, think about it again and try to search for more information about it when you go home.
Now, what does photosynthesis produce?
- M12: Food and oxygen.
- T: What is the main product of photosynthesis? Food or oxygen?
(Some said "food" and some said "oxygen")
- C1: Oxygen is more important. If not they will die. They need oxygen to breath.
- C4: Food! They produce food so that they can survive.

- T: Imagine if there is no food produced at the end, what will happen to the plants?
- M14: Emm.... The plants will die.
- T: If the plants do not produce oxygen?
- C5: Er, plants will die too.
- C6: I think the main purpose is to produce food. They still can get oxygen from the surroundings, if available.
- M10: I thought plants turn carbon dioxide and water into oxygen during photosynthesis, without producing food...
- C6: No, the main purpose of plants carrying out photosynthesis is to produce food. Oxygen is produced too, but it is just the by-product. Carbon dioxide, water and sunlight are used to produce food during photosynthesis.
- T: So, what is the definition of photosynthesis?
- C6: Plants use water, carbon dioxide and sunlight to produce food.

The discussion was dominated by active or good learners. Passive learners were given more wait-time but still they gave less responses than expected. They are able to voice out which character they thought was correct but they were unable to explain their views or the reason for their answers during the discussion. They preferred to follow the discussion with great attention instead of giving their opinions. They were more comfortable with one-to-one interviews during which they were able to voice their way of thinking with an appropriate wait-time given. The teacher gave more guidance than expected as it was the first time pupils were exposed to discussions in class. However, the teacher only acted as facilitator or question poser during the discussions.

The teacher also noticed difficulties to lead the discussion on the misconception that “Only green plants can undergo photosynthesis”. It is because the concepts needed to remedy this misconception have not been taught before in the Year 4 syllabus. They had not been exposed to microorganisms or other classification of organisms, other than plants and animals. Even in the Year 4 textbook, fungi are considered as plants in the topic of “Way of Reproduction of Plants”. It is hard to eliminate a misconception that is constructed based on another misconception. The topic of “Basic Needs of Plants” in Year 4 also leads to pupils’ confusion about the concept of food source of photosynthesis. Pupils tend to think that the basic needs (sunlight, air and water) are equal to food source as they are needed to produce food.

The effectiveness of teaching using *Concept Cartoons* does not seem to only stem from the *Concept Cartoons* themselves as a teaching tool but depend on the quality of classroom interactions during the discussion and investigation phase of the teaching (Kabapinar 2005). Thus, the quality of interactions during the discussions has to be improved in order to maximize the effectiveness of *Concept Cartoons*. So, the teacher who is trained in this area might produce a better result.

2.5.2 Interview Responses

A total of 25 out of the 29 pupils mentioned that they liked the *Concept Cartoons*. These students stated that they liked learning science using *Concept Cartoons* because it was interesting and the cartoons attracted their attention. Only four pupils commented negatively about the *Concept Cartoons*. They said that it was boring. This might be because the pupils still could not adapt to the newly implemented teaching–learning method since they were used to a teacher-centred spoon-fed learning method. They were still not familiar with the discussion method, thus were reluctant to participate actively in the discussions and hence got bored easily.

Furthermore, the characters in the *Concept Cartoons* portrayed peoples of other countries, which were not very relevant to the pupils in the context of Malaysia. So, it is suggested that in order to attract more attention from the pupils, the characters of the *Concept Cartoons* should be characters that the pupils are familiar with and similar to their own culture and context. Based on the responses of the pupils with misconceptions obtained during the interviews, it is possible to say that the use of *Concept Cartoons* in science education is efficient. In the following section, some examples of the pupils' interview responses are provided:

(T- Teacher, M: Students with misconceptions; C: Students without misconceptions)

- M1: I used to think that vitamins are the food for the plants but it seems that I was wrong. Vitamins only help the plant to grow and it was not the food for the plant. The plants can actually produce their own food.
- T: When did you realize that you were wrong?
- M1: I realized my mistake after listening to my friends during the discussion. Both vitamins and fertilizers are not the food for the plants. They only helped the plants to grow better.
- M2: All this while, I thought that fertilizers are the foods of the plants because the plants grow well after my mum put fertilizers around the plants. It is actually incorrect as the plants produce their own food and fertilizers are not the food for the plants.
- T: When did you realize it?
- M2: I realized it when my friends corrected me during the discussion and said that fertilizers are not the food for the plants. The plants produced their own food, not getting food from their surroundings like animals.
- M4: After listening to C1 and C4 during the discussions, I learned that soil was not the food for the plants. The food does not come from the soil and the plant can live without soil. The plant only gets vitamins and water from the soil. They produce their own food.
- M5: Before this, I thought that plants produce chlorophyll. They exhale oxygen and inhale carbon dioxide during photosynthesis. During the discussion, I realized that chlorophyll is not produced during photosynthesis and oxygen is not the most important product of photosynthesis. The most important

- product is food. Not only carbon dioxide, but also sunlight and water are used to produce food during photosynthesis.
- M8: I know that plants produce their own food through photosynthesis. But I was sometimes confused and thought that sunlight, water and carbon dioxide are the foods of the plants because the plants need them to undergo photosynthesis. However, I am now very clear that they are only the things needed by the plants to carry out photosynthesis but are not the food for the plants. The plants used them to produce their own food through photosynthesis. I only realized my confusion when I tried to explain that fertilizers are not the foods of the plants to my friend and my teacher asked what the food for the plants was if fertilizers are not, during the class discussion. I noticed that my explanation contradicted my own answer during the first interview. Actually, we learned that plants produce their own food before but I just remembered it wrongly and was confused with it sometimes.
- M9: I said that photosynthesis produces carbon dioxide and chlorophyll. However, I was not correct. During the discussion, my friends mentioned that chlorophyll is not produced during photosynthesis, but food and oxygen are...
- M10: Before the class discussion, I did not know that photosynthesis produced food. I thought that photosynthesis is a process in which plants turn carbon dioxide and water into oxygen. I realized my mistake during the class discussion.
- M11: Photosynthesis produces food, carbon dioxide and chlorophyll.
- T: Are you sure? Did you pay attention during the class discussion?
- M11: Erm... I actually got bored with the discussion and did not pay much attention to it...

Tables 2.2 and 2.3 show the comparison of responses of the pupils to the questions “What are the food sources of plants?” and “What is photosynthesis?”

Table 2.2 Comparison of responses of the pupils to the question “What are the food sources of plants?” during the in-class discussions and interviews referring to Figs. 2.2 and 2.3

The character in the <i>Concept Cartoons</i> that pupils agreed to	A	B	C	D	E	*F	G
Number of pupils (In-class discussions)	1	2	3	3	2	11	7
Number of pupils (Interviews)	0	0	0	0	2	22	5

* Respondents with the correct concept about the subjects in the *Concept Cartoons*.

Table 2.3 Comparison of responses of the pupils to the question “What is photosynthesis?” during the in-class discussions and interviews referring to Figs. 2.4 and 2.5

The character in the <i>Concept Cartoons</i> that pupils agreed to	A	*B	C	D	E	F	G	H	I	J
Number of pupils (In-class discussions)	7	12	0	0	2	2	2	2	2	0
Number of pupils (Interviews)	0	23	0	0	2	2	1	1	0	0

during the discussions and interviews. The alphabets with an asterisk refer to the respondents with the correct concept about the subjects in the *Concept Cartoons*.

Based on the comparison of the pupils' responses to the questions "What are the food sources of plants?" and "What is photosynthesis?" obtained from the class discussions and interviews, we can conclude that the pupils' understanding about the subject had improved with the use of *Concept Cartoons*.

During the interviews, most of the pupils stated that plants produced their own food and plants produced food by photosynthesis using carbon dioxide, sunlight and water. They also stated that they became aware of their incorrect conceptions by participating in or listening to the in-class discussions. Nevertheless, there were some pupils who still did not overcome their misconceptions about the subject photosynthesis.

2.6 Discussion

Concept Cartoons were created approximately 20 years ago (Naylor and Keogh 2012). The use of *Concept Cartoons* in diagnosing and remedying misconceptions in science is not new. A number of studies have been carried out to find out the effectiveness of *Concept-Cartoons* in diagnosing and remedying misconceptions (Ekici et al. 2007; Kabapinar 2005; Taşlıdere, 2013). Therefore, in this study, the effectiveness of *Concept Cartoons* in diagnosing and reducing primary school students' misconceptions related to photosynthesis was examined.

Kabapinar (2005) and Ekici et al. (2007) proposed that *Concept Cartoons* are effective in diagnosing and remedying misconceptions. Findings of our study are supported by findings that are reported in the literature. Moreover, the literature also mentioned that *Concept Cartoons* are effective in setting up a debate, inviting cognitive conflict, inspiring dialogue, eliciting and restructuring pupils' ideas (Dabell 2008; Dündar and Şentürk 2012; Naylor and Keogh 2012). Learners are also encouraged to compare and contrast, to look for evidence and justify their own reasoning in response to the characters in the cartoons (Dabell 2008). These claims in the literature were also compatible with our findings, especially in the in-class discussions where pupils questioned their friends' ideas as well as their own ideas. Students were noticed to restructure their own ideas and built on one another's ideas to achieve a more comprehensive understanding.

Besides that, the assertions of many researchers which are supported by our study are as follows: *Concept Cartoons* promote pupils' participation (Dabell 2008; Dündar and Şentürk 2012), act as a stimulator for the formation of a discussion environment in the lessons (Dündar and Şentürk 2012), promote involvement (Dündar and Şentürk 2012; Kabapinar 2005; Keogh and Naylor 1996) and create interactive learning environments (Naylor and Keogh 2012). The findings of our

study are in parallel with the ideas in the literature. Most of the pupils participated in the discussions and pupils interacted with one another actively during the discussions. However, there were still some pupils who were reluctant to join the discussions, especially the discussion about the definition of photosynthesis. This is because they are used to being spoon-fed and are not familiar with participating in discussions. They were not used to expressing their views. Thus, the smart learners seemed to dominate the discussions about the definition of photosynthesis as they were more confident and outspoken. More time and lessons using *Concept Cartoons* have to be implemented in order to get all the pupils to be familiar with the new method and join the discussion actively.

Furthermore, *Concept Cartoons* are more effective when discussed in a mixed-ability group of learners because this results in a greater degree of exchange and allows different ideas to surface, which can then be debated (Dabell 2008). Similarly, in this study, a mixture of students with three levels of learning ability (high achievers, intermediate and low achievers) allowed students to share and debate the arguments and assisted the ones with wrong understanding to correct their conceptions. During the class discussions, the slow learners' misconceptions emerged when they agreed with the characters with misconceptions in the *Concept Cartoons*. Pupils with the correct conceptions also expressed their ideas and this led to the exchanging of ideas among the pupils. Then, the pupils with the correct conceptions took the role of challenging their peers' ideas and remedying their peers' misconceptions during the discussions.

The findings of the study also support the ideas that *Concept Cartoons* promote positive attitudes to science teaching and learning (Keogh et al. 2002) and promote motivation (Keogh and Naylor 1996). The findings of both the class discussions and one-to-one interviews show that the study is compatible with the literature. The pupils enjoyed the science lessons utilizing *Concept Cartoons*, having more interest towards science lessons, and their motivation was enhanced. However, it was noticed that the *Concept Cartoons* used during the in-class discussion did not really lead to investigation by the pupils on the topic to the extent as was reported in the other previous studies (Dündar and Şentürk 2012; Kabapinar 2005; Keogh and Naylor 1996). This may be due to the relevance of the characters to the pupils' own context. The pictures in the *Concept Cartoons* did not reflect the pupils' real scenarios and also most pupils are used to being spoon-fed by teachers instead of being self-learners in the learning process. So, they are not motivated to find the answers on their own. However, a change of concepts was noticed after the in-class discussions.

On the other hand, there were still some misconceptions that could not be remedied. This is because misconceptions are deeply penetrated into students' minds and are resistant to change (Küçüközer and Kocakulah 2007). Due to time constraints, the use of *Concept Cartoons* in class discussions was only implemented once in this study; thus, some pupils still resisted to change their misconceptions. More time and lessons are needed in order to remedy the misconceptions of all the

pupils. Nonetheless, most pupils have remedied their misconceptions about the subjects after the intervention.

2.7 Conclusion

The findings of this study show that *Concept Cartoons* can be used to diagnose and eliminate misconceptions about photosynthesis. Misconceptions found in this study are similar to the misconceptions in the literature. The number of misconceptions which have been eliminated is quite high. Besides, since *Concept Cartoons* involve the use of a constructivist approach in teaching science, it is suggested that *Concept Cartoons* be used in textbooks after identifying pupils' misconceptions for particular subjects through surveying the literature. Furthermore, further research related to *Concept Cartoons* should be conducted to study whether or not the skills of the teachers in leading discussions affect the effectiveness of using *Concept Cartoons* in teaching, to explore the use of *Concept Cartoons* in another topic, to investigate the effectiveness of *Concept Cartoons* as teaching materials over a longer term and the use of *Concept Cartoons* in eliminating a misconception that is built on another misconception. Despite the findings of the study which show that *Concept Cartoons* are effective in overcoming misconceptions about photosynthesis, the study exhibits several limitations. One of the prominent limitations of the study is that it lacks generalizability. Since it is a case study involving a small number of participants, the findings from this study may not be generalized to other contexts. To improve the generalizability, it is strongly suggested that the study to be replicated in other primary schools in Malaysia. Additionally, interviews are the only method used in this research to identify the effects of *Concept Cartoons* on reducing the misconceptions. Although through interviews substantive reasons behind the misconceptions could be ruled out, since this study involves primary school students, it would have been appropriate if the study also included some quantitative findings involving larger samples. There are possibilities that the students have misinterpreted the interview questions. With the inclusion of quantitative findings, there are possibilities for the misinterpretations to be eliminated. In this study, only limited Cartoons were used. This is also another limitation.

References

- Chin, C., & Teou, L. Y. (2009). Using concept cartoons in formative assessment: Scaffolding students' argumentation. *International Journal of Science Education*, 31(10), 1307–1332.
- Dabell, J. (2008). Using concept cartoons. *Mathematics teaching incorporating micromath*, 209, 34–36. Retrieved from <http://niagamethods.wikispaces.com/file/view/~Dabell~Using+concept+cartoons.pdf>
- Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Research*, 23(7), 5–12.

- Dündar, H., & Şentürk, M. L. (2012). Concept cartoons and their using in life studies lesson. *Uşak Üniversitesi Sosyal Bilimler Dergisi*, *Güz* (5/3). Retrieved from http://sosyaldergi.usak.edu.tr/Makaleler/1792478773_201203makale3.pdf
- Ekici, F., Ekici, E., & Aydın, F. (2007). Utility of concept cartoons in diagnosing and overcoming misconceptions related to photosynthesis. *International Journal of Environmental & Science Education*, *2*(4), 111–124.
- Gooding, J., & Metz, B. (2011). From misconceptions to conceptual change: Tips for identifying and overcoming students' misconceptions. *The Science Teacher*, *78*(4), 34–37.
- Ingec, S. K. (2008). Use of concept cartoons as an assessment tool in physics. *US-China Education Review*, *5*(11), 47–54.
- Kabapınar, F. (2005). Effectiveness of teaching via concept cartoons from the point of view of constructivist approach. *Educational Sciences: Theory and Practice*, *5*(1), 135–146.
- Keogh, B., & Naylor, S. (1999). Concept cartoons, teaching and learning in science: An evaluation. *International Journal of Science Education*, *21*(4), 431–446.
- Keogh, B., & Naylor, S. (1996). *Teaching and learning in science: a new perspective*. Paper presented at the BERA Conference, Lancaster, UK.
- Keogh, B., Naylor, S., de Boo, M., & Rosemary, F. (2002). Formative assessment using concept cartoons: Initial teacher training in the UK. In H. Behrendt, H. Dahncke, R. Duit, W. Gräber, M. Komorek, A. Kross, & P. Reiska (Eds.), *Research in science education—Past, present, and future* (pp. 137–142). New York: Kluwer Academic Publishers.
- Köse, S. (2008). Diagnosing student misconceptions: Using drawings as a research method. *World Applied Sciences Journal*, *3*(2), 283–293.
- Küçüközer, H., & Kocakulah, S. (2007). Secondary school students' misconceptions about simple electric circuits. *Journal of Turkish Science Education*, *4*(1), 101–115.
- Naylor, S., & Keogh, B. (2012). *Concept cartoons: What have we learnt?* Paper presented at the Fibonacci Project European Conference, Leicester, UK.
- Sexton, M. (2010). *Using concept cartoons to access student beliefs about preferred approaches to mathematics learning and teaching*. Freemantle, Australia: Paper presented at the MERGA conference.
- Saka, A., Akdeniz, A. R., Bayrak, R., & Asilsoy, Ö. (2006). “Energy conversion in living” impact of the elimination of errors faced in unit concept cartoon (Trans.). Paper presented in National Science and Mathematics Education Congress 6–8 September 2006, Ankara, Turkey.
- Taşlıdere, E. (2013). Effect of conceptual change oriented instruction on students' conceptual understanding and decreasing their misconceptions in DC electric circuits. *Creative Education*, *4*(4), 273–282.
- Tlala, B., Kibirige, I., & Osodo, J. (2014). Investigating grade 10 learners' achievements in photosynthesis using conceptual change model. *Journal of Baltic Science Education*, *13*(2), 155–164.
- Yenilmez, A., & Tekkaya, C. (2003). Enhancing students' understanding of photosynthesis and respiration in plant through conceptual change approach. *Journal of Science Education and Technology*, *15*(1), 81–87.

Overcoming Students' Misconceptions in Science

Strategies and Perspectives from Malaysia

Karpudewan, M.; Md Zain, A.N.; Chandrasegaran, A.L.

(Eds.)

2017, XVI, 344 p. 52 illus., Hardcover

ISBN: 978-981-10-3435-0