Concept Cartoon as a Teaching Technique for Conceptual Change: A Ghanaian Junior High School Experience

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Abstract  This study investigated the use of concept cartoons to diagnose and remedy pupils’ misconceptions in selected science concepts. The sample comprised 37 Junior High School (JHS) pupils and one science teacher in Abelemkpe Junior High School in the Greater Accra Region of Ghana. Completed worksheets of pupils on concept cartoons of selected science topics were discussed and analyzed to find out their misconceptions about the concepts under study. Results revealed that pupils had a host of misconceptions on the concepts. During class and group discussions, the pupils had the opportunity to compare their original ideas with the ones in the cartoons. They also listened to their peers’ explanations about the correct science concepts and built on their initial conceptual framework. These enabled the pupils to correct their misconceptions in an interactive environment through concept-cartoon based instruction. The results showed that concept cartoons could be used to determine pupils’ misconceptions of selected science topics to enable appropriate interventions to be designed to address them when possible. Concept cartoon is therefore recommended to be used by JHS teachers to teach science effectively.

Keywords: concept cartoons, misconceptions, constructivist learning, conceptual change


1. Introduction

Ref. [1] is of the view that pupils are repertoire of ideas and principles which they bring to the learning environment. This stock of ideas and principles are like two edged swords, they either support or hinder the concept being taught. Pupils therefore, come to class with something in mind. Reference [2] asserts that what pupils already know has significant impact on them; what they learn in school is conditioned by this previous knowledge which can be as destructive as what they don’t know. Children before they enroll in school are energetic cognitive agents through their formative years. They come to the classroom with substantial knowledge based on instincts, every day experiences, and what they have learnt from their cultural perspectives. Ref. [1] asserts that misconception or alternative conceptions should not be disregarded though they are wrong ideas based on faulty thinking. These wrong conceptions are common among learners and are a significant part of the learning because they can form the foundation of new learning. This was emphasized by [3] that misconceptions are not uncommon and are a normal part of the learning process. Pupils naturally form concepts from their daily experiences, but not all the ideas they develop are accurate with respect to the most current knowledge. Ref. [3] further indicated that misconceptions can certainly hinder learning for the following reasons:

1. Students are oblivious of the fact that the knowledge they have is faulty.
2. Misconceptions can be deep-rooted in student thoughts.
3. Students interpret new learning through these inaccurate understandings resulting in an interference with the ability to properly comprehend new information.
4. Misconceptions tend to be very impervious to teaching because learning should result in transformation in student’s thinking and attitude.

Conceptual change therefore, has to occur for learning to take place. Researchers have claimed over the years that the awareness teachers have about students’ common misconceptions is critical to students learning [4] with the reason that “learning is as much about unlearning old ideas as it is about learning new ones [5]; “This puts teachers in a very challenging position of needing to bring about significant conceptual change in student knowledge” [3]. Learners often find it difficult to change their misconceptions, since they have held these ideas for a long time and they make sense to them. Some researchers therefore, strongly believe that teachers must have an idea of students’ misconceptions for the topics that they teach [6]. After assessing student preconceptions about a
concept, it is important to consider which components of their acquired knowledge could be beneficial in building a stronger understanding of new concepts. Though it may seem that misconceptions are only a barrier to learning, when used properly, they could serve a productive purpose in the classroom [7]. It is important to check for faulty prior knowledge regularly so that it does not detract pupils from learning the science concepts.

One way of structuring lessons to bring out pupils’ misconceptions is the use of the conceptual change constructivist approach. According to the constructivists, “learning is an active process where learners make meaning and interpret situations from their past knowledge and experiences” [8]. In a constructivist learning environment, the teacher plays the role of a guide and helps students to connect their prior knowledge with new information. Instructional materials that are developed for learning and teaching have an important role in creating a constructivist classroom environment [9]. Learning materials must be prepared and used for meaningful learning outcomes [10,11,12]. One of such learning materials is the concept cartoon within the context of the 5Es instructional model. Therefore, this study looks at the use of concept cartoons to diagnose and correct pupils’ misconceptions on mixtures, heredity, osmosis and diffusion. Research question to guide this study are:

1. What ideas do the pupils bring to the study of the mixtures, heredity, osmosis, and diffusion?
2. Will the use of concept cartoons through the 5E instructional model diagnose and correct pupils’ misconceptions on mixtures, heredity, osmosis and diffusion?

2. Review of Literature

2.1. Conceptual Change

Students consciously or unconsciously enter a learning situation with some level of prior knowledge that can affect their present learning experience. When this prior knowledge is correct, it can help students learn new concepts. However, when this knowledge is incorrect, it will impede learning. The incorrect prior knowledge can pose a challenge to learning because it is often strong, can twist understanding and prevent students from conceptual change. Conceptual change is necessary for effective learning.

Ref. [13] defined Conceptual change as learning that changes an existing notion, belief, idea, or way of thinking. Learning for conceptual change is not merely accumulating new facts or learning a new skill but a shift or restructuring of existing knowledge and beliefs which become a framework that students use to solve problems or explain phenomenon. Davies further indicated that teaching for conceptual change primarily involves two processes; uncovering students’ preconceptions about a particular topic and using techniques to help students change their conceptual framework. Teachers must therefore be abreast with instructional strategies which enables them to act as facilitators rather than the transmission of information. Ref. [14] asserts that presenting a new concept or telling the learners that their views are inaccurate will not result in conceptual change because preconceptions are resistant to change. Learners may not easily discard their ideas and adopt a new way of thinking since they have relied on these existing notions for a considerable period of time to appreciate and function in their world.

Teaching for conceptual change therefore, requires a constructivist approach in which learners take an active role in reorganizing their knowledge. Cognitive conflict strategies, derived from a Piagetian constructivist view of learning, are effective tools in teaching for conceptual change. These strategies involve creating situations where learners’ existing conceptions about particular phenomena or topics are made explicit and then directly challenged in order to create a state of cognitive conflict or disequilibrium [14]. One of such strategies is concept cartoons.

2.2. Concept Cartoons

Concept cartoons are cartoon style drawings designed as a stimulus to question, to intrigue, to provoke discussion and to generate scientific thinking among pupils. Concept cartoons provide a range of viewpoints and are based on the constructivist approach [15]. Generally, concept cartoons in science education can be used to: determine and remedy students’ misconceptions, provide opportunities for the active participation of students in the learning process, create a discussion environment, remind students of their existing knowledge and enable them to express their ideas. These opportunities are offered when the use of concept cartoons during instruction is within the context of the 5Es instructional Model. The 5Es instructional model which falls within the theories of constructivist teaching model is a sequence of stages teachers may go through to develop scientific understanding of a concept. This model enables students to go beyond what they can do independently. Every element of the five “E” is carefully created to promote learners’ construction of knowledge. The concept behind the model is to begin with students’ current knowledge, make connections between current knowledge and new knowledge, provide direct instruction of ideas the students would not be able to discover on their own, and provide opportunities to demonstrate understanding [16].

Concept cartoons elicit learners’ ideas and are valuable tool for developing learners’ ideas. Usually, learners readily engage in discussion when Concept Cartoons are used, and as they attempt to justify their ideas, they expose their views to the possibility of challenge by their peers. In looking for evidence and constructing suitable arguments to justify their ideas, learners often come to recognize for themselves their limited and more productive ways of understanding the situation [17]. Utilizing concept cartoons in classroom instruction can reveal misconceptions pupils have about particular concepts [18]. The use of concept cartoons puts pupils in a position to question their ideas, improve their thinking ability and analyze events from diverse angles, in this way, misconceptions can be identifiable and corrected. Concept cartoons are more effective when discussed in a mixed-ability group of learners. This is because it promotes a
greater degree of exchange of ideas among pupils and generates differences from pupils which can then be debated [19]. The JHS where there is a mixture of pupils with different levels of learning ability (high achievers, intermediate and low achievers), pupils are allowed to share and debate the arguments and assist the ones with wrong understanding to correct their conceptions. One of the hindrances to effective learning of science is pupils’ misconceptions which in most instances are left unaddressed probably because science teachers do not realize this hinders effective teaching and learning. It is therefore, imperative that teachers use strategies and teaching aids that can diagnose and remedy pupils’ misconceptions.

3. Methodology

3.1. Research Design

The purpose of this research was to use concept cartoons adapted to the 5E instructional model to diagnose and remedy misconceptions junior high school pupils have about some science concepts. Case study was considered to be a suitable design for investigating the research questions with action research chosen as the most appropriate research approach because it allows the intervention strategy or design to be studied during its enactment. Features that emerge during the enactment inform changes to the strategy and allow the understanding of underlying learning issues [20]. According to Tabak, action research contributes to the development of effective learning environment and using such environment as natural laboratories to teach (as cited in [21]). It involves taking action to improve teaching and learning with orderly study of the action and its consequences. There are a number of action research models but this study adopted [22] model. He distinguishes five phases of action research to be conducted. Initially, a problem is identified and data is collected for a more detailed diagnosis. This is followed by a collective postulation of several possible solutions, from which a single plan of action emerges and is implemented. Data on the results of the intervention are collected and analyzed, and the findings are interpreted in the light of how successful the action has been. At this point, the problem is re-assessed and the process begins another cycle.

3.2. Sample

The target population was JHS pupils in the Greater Accra Region of Ghana. The study sample was an intact class of 37 JHS form two pupils together with their science teacher.

3.3. Research Instruments

The instruments used in this study were observation schedule and concept cartoons. Observation was done prior to the implementation of the action plan to have an idea of teaching strategies used by the integrated science teachers in the classrooms, ideas pupils brought into the learning situation and how the teacher addressed these ideas. The researcher was a non-participant observer during classroom observation before the intervention. There was also classroom observation during the enactment of the intervention to find out how pupils could work independently with minimum support, their eagerness to learn and their involvement in the lesson among others. Concept cartoons representing four topics (mixtures, heredity, osmosis and diffusion) were prepared by the researcher and used to elicit and remedy pupils’ misconceptions about the concepts under study.

3.4. Intervention

Four different concept cartoons representing four different topics (mixtures, heredity, osmosis, diffusion) were prepared by the researcher and used in a junior high school form two class. The pupils had no experience with concept cartoons. They did have some knowledge in the concepts depicted in the concept cartoons because they had encountered these concepts at the upper primary level. The concept cartoons were prepared on sheets of papers together with worksheets [23] and adapted to the constructivist 5E Model. Each concept cartoon of instruction came either with a short story or a question for action. The cartoons represented characters with their reported ideas on the topics in form of stories and problems to be solved. Pupils were put into groups and each group was handed a concept cartoon paper with a short introduction to help them understand the use of the concept cartoons. Each group was also given a worksheet to be completed while they went through the lesson. The worksheet was organized according to the stages of 5E Model engagement stage, exploration stage, explanation stage, elaboration stage and evaluation stage).

3.4.1. Engagement Stage

This is the initial stage of the learning process where the pupils first encountered the instructional task. Pupils were put into groups of 5/6 and the concept cartoons with an intriguing short story, demonstration or questions related to the topic was introduced to them. The cartoons had different responses to the questions asked. The prior knowledge of pupils was identified at this stage through the concept cartoons that were designed to the curiosity of the pupils, to capture their interest and to engage them in discussion. After reading the story or observing the phenomenon, the pupils discussed the views of the cartoons and identified the cartoon they thought had the right view and gave reasons for their choice of answer. Their predictions and reasons were written on the worksheet.

3.4.1.1. Lesson on Diffusion

Each group was given concept cartoons on diffusion. The cartoon had a beaker with water and a crystal of potassium permanganate crystal dropped in the water. They were asked to explain what would happen to the crystal dropped in the water. Pupils were to choose from the responses of the cartoons which they thought was appropriate. They then recorded their predictions on the worksheet.
3.4.1.2. Lesson on Heredity

Pupils were given a story problem about a couple with six children. One of the children who happened to be the first born had a different complexion from the rest who have same complexion. Also, she had a blood group which did not match that of her parents or siblings. Pupils were to find out if this girl was the daughter of the father or another man’s daughter. They were asked to discuss the story and answer the questions on the worksheet. This was a topic that did not lend itself to experimentation but rather provoked discussion.
Figure 3. Cartoon ideas on heredity

3.4.1.3. Lesson on Osmosis

Pupils were given a story about a sister who kept lettuce in salt water when she was preparing vegetable salad. The vegetable became weak after few minutes.

Pupils were asked what happened to the vegetables. Pupils were asked to discuss as a group and choose which cartoon response they thought was right then proceeded to design and conduct an experiment to confirm their group’s claim.

My sister kept lettuce in salt water when she was preparing vegetable salad. She left the rest of the lettuce in ordinary water. After some minutes, she observed that the leaves in the salt water were not as they were when she bought them, they have become weak and they ones in ordinary water looked very fresh and firm. What happened to the leaves in salt water?

Figure 4. Lesson on osmosis
3.4.1.4. Lesson on Mixtures

Each group was given a story about a lady cooking and out of excitement a whole bottle of granulated salt was poured into water, she didn’t act fast so the salt dissolved in the water. Pupils were asked if the salt could be separated from the water and how this could be done. Pupils discussed and chose which cartoon’s response they thought was right. They then gave reasons for their choice of cartoon response.
3.4.2. Exploration Stage

The Pupils at this stage were directly involved with activities and materials in order to confirm or disconfirm the predictions they made at the engage stage. Involving themselves in these activities they developed a grounding of experience with the phenomenon. This phase consisted of hands-on activities and group discussions in which they explored the concept or skill. They dealt with the problem or phenomenon and described it in their own words. This stage provided a common set of concrete experiences upon which students continue building concepts, processes and skills [24]. According to Temizyurek (as cited in [21]) students try to understand and explore the subjects through their own experiences and thoughts, by making and testing hypotheses, so that they can compare results and ideas with their classmates. The researcher was a facilitator, providing materials and guiding the students’ focus. Also, she observed and listened to the pupils critically as they interacted and shared ideas. The pupils interacting and sharing ideas meant that cooperative learning was employed in this phase which led to intelligent discussions among the pupils. To meet this stage’s requirements, cartoon characters helped pupils in the groups to perform experiments related to the topic or provide the basis for discussion to come out with their findings. In some cases, the pupils replicated the experiment shown in the cartoon; in other cases, they came up with a new experiment by changing one variable. Some of the concept cartoons proved to provoke discussion, whereas others stimulated the pupils to design experiments. The researcher provided materials the pupils needed for the experiments. This gave pupils who had little or no experience in designing and conducting scientific investigations ideas on what to look out for or do during the exploration stage. However, pupils struggled and could not effectively write description and results because they had little or no experience in designing and conducting scientific investigations. They had to call the researcher’s attention before they could put some ideas together on paper. This stage was very important in restructuring the pupils’ prior knowledge and thinking structures. Activities performed at this stage were described and recorded on the worksheet.

3.4.2.1. Experiment on Diffusion

During the lesson on diffusion there were variations between the groups in terms of designing the experiment. Pupils were asked what would happen to a blue crystal dropped into a beaker of water. These were some of the responses:

- “Obolo is right because all the crystal molecules will spread from a region of lower concentration to a region of higher concentration which may result in homogenous distribution”
- “Obolo is right because the crystal is moving into the water with a high force rate and the density of water is high”
- “Obolo is right because the crystals will dissolve and spread to every corner of the container with water. For example, sugar (crystals) dissolve in water”

The pupils designed a wide variety of experiments. Few of the groups replicated the experiment shown in the cartoon while others changed one variable. For instance, a group asked for ice block to demonstrate ‘diffusion’ of solid in water, another designed it using salt or granulated sugar to demonstrate ‘diffusion’. When asked if their experiment worked in order to confirm their claim, they indicated that it did not because they didn’t see the molecules moving. A group’s claim was that both the water and the crystal moved to all corners of the beaker. They noted, however, that their experiment did not confirm their claim because they saw only the crystal move.
2.4.2.2. Experiment on Mixtures

The pupils discussed and chose which cartoon response they thought was right, gave reasons for their choice and proceeded to conduct an experiment to confirm their group claim. Some responses of the pupils are presented below:

“Afua is right because when we put the mixture on fire it will evaporate faster and the salt will remain”

“Evaporation is the process of separating some solid mixtures form liquid mixtures and it can be used to separate the salt from the water”

“If you put the salt water on fire the water gets heated while on fire and rise into the atmosphere and Abena will get the salt back”

The experimental designs were almost the same in all the groups except two groups which had wrong drawings. These groups had, for instance, a drawing of separating a mixture using a water bath. They designed the experiment with wire gauge, tripod stand, Bunsen burner, evaporating dish and water bath. This was the process they outlined:

- We will put a Bunsen burner under the tripod stand to produce heat and place a wire gauge on the tripod stand and place a water bath containing water on it.
- The evaporating dish containing the mixture is then placed on the water bath.
- We expect to see the water in the bath boiling causing the mixture in the evaporating dish to boil.
- We will see vapours rising from the evaporating dish and we will get the salt.

This group meanwhile, conducted the experiment without the water bath. They couldn’t answer when asked how they could use a water bath to separate a mixture of salt and water, they then realized their mistake that an evaporating dish placed on a water bath is not an appropriate way of separating mixtures.

Five other designs their experiment by using beakers or evaporating dishes, Bunsen burners, tripod stands and mixture of salt and water. They expected that the water, after boiling, would evaporate leaving the salt. Their claim was confirmed after their experiment.

2.4.2.3. Experiment on Osmosis

This lesson started with heated discussions among group members which led to anger and confusion in some groups. Sanity was restored after the researcher and the science teacher intervened. Three groups indicated that ‘carrot’ was right. The reasons they gave were that “salt is so strong that it can even destroy saucepan when it is kept in it for a long time so it can kill cells in a vegetable within minutes”. Another group also said “salt can cause fish to dry and can be preserved for months so can kill the cells in the leaves”.

Three of the groups indicated that ‘cabbage’ was right. The reason two groups gave was that salt is poisonous because it has changed the structure of the leaves. One of the groups did not give any reason for their claim.

Two groups also indicated that ‘tomato’ was right. One of these two groups did not give any reason, the other group however did indicate that the “salt water was too concentrated for the water in the lettuce so the lettuce lost water to the salt solution”.

All the groups carried out their experiment to confirm their claims. The experiment was the same for all the groups. All the groups asked for salt, water and a vegetable to perform the experiment. The pupils performed the experiments and recorded their observations but could not explain their observations except the group that indicated that the leaves lost water to the salt water which is concentrated. The pupils however, had difficulty in filling spaces on the worksheet for this experiment. When asked why, they had the difficulty of explaining what happened to the leaves.

The researcher then gave them yam, water, salt and a bowl to perform another experiment. She gave them instructions on what to do. They went ahead to perform the experiment and recorded their observation. This experiment which was done to demonstrate osmosis in living tissue caused the pupils to understand the movement of water molecules from a region of lower concentration to a region of higher concentration. Here, the pupils were able to indicate that water moved from the basin into the yam since they saw an increase in the quantity of water in the yam while the water in the basin decreased. From this experiment pupils then appreciated the fact that tomato was right to say that the lettuce lost water to the concentrated salt water.

Non-experimental activity on heredity

This was a topic that did not lend itself to experimentation but rather provoked discussion. The pupils eagerly read the story with none idle. The enthusiasm and the level of participation were very high. Every member of each group had something to say about the work. One group could not agree on any of the views of the cartoons so decided to vote on the responses. Most of the pupils indicated that Efua was right as the girl took after one of the ancestors. They gave various reasons for their claim.

A group said “it is possible children do not inherit the characteristics of their parents but rather their grandparents or any member of their extended family.”

Another group said “a child doesn’t necessarily need to look or take after one of their parents for people to see that they are their biological children”. They further concluded that the girl is an albino.

Two groups indicated Kofi was right, speculating the mother got pregnant for another man before marrying Okpoti papa. They gave the following reasons:

“Maybe the mother got pregnant for another man before she got married to Okpoti papa but she didn’t know”

“Or a man and a woman can’t give birth to six children with five same blood group but one with different blood group”.

Another group said “it is because we all know that a family is made up of people related with the same blood but according to the story Abinana’s blood group is different from that of the family so that is why I think Kofi is right”.

Through this activity the preconceptions of the pupils about heredity were revealed. The pupils had different
ideas about how characters are inherited from parents to offspring.
A group said “characters are inherited through blood and nutrients”.
Another group said “children copy the characters from their parents when they are growing up”.
This is what one other group wrote “traditionally it is believed that when a pregnant woman usually sits or does things with a particular person constantly the child in the tummy may take after the person but scientifically it is believed that children take after their parents through genes”. The rest of the groups indicated that characters are inherited through genes.
In explaining why children looked like or do not look like their parents, they said children look like their parents in order to prevent people from thinking that they are not the biological children of their parents. A group wrote that “the children look like their parents because the DNA of the child chose the face of the parent or even sometimes it takes the grandparents”. Five groups indicated that children look like their parents because of inheritance through genes. Children they said do not look like their parents because of the following reasons:
- they sometimes take after their ancestors.
- the mother during her pregnancy was around a particular person so the child looks like that person.
- the mother got pregnant for another man before marrying the husband.
- they did not inherit any gene from their parents.

3.4.3. Explanation Stage
This was the phase of teacher-led instruction in the form of guided teaching. The Researcher became active at this stage. She introduced scientific terms as labels for pupils’ ideas and provided content information, corrected mistakes and guided the pupils to complete the missing parts in their outcomes, confirmed or disconfirmed pupils’ knowledge. The learners had a chance to compare their newly structured ideas with those presented by the researcher. Also, the learners began to put the abstract experiences into communicable form. Communication occurred between pupils, the researcher, or within the pupils themselves. Working in groups, the learners supported each other’s understanding as they articulated their observations, ideas, questions and assumptions. The significant aspect of this phase was that explanation followed experience. Knowledge that students had learned at the exploration stage was very important for this phase. Pupils were made to answer some questions from the activities they performed. For example, “According the experiments above, describe ................?” By having pupils answer the questions researcher was able to reveal pupils’ understandings about the concept. By doing this activity, the researcher had a chance to correct misconceptions when pupils gave a wrong description.

3.4.4. Elaboration Stage
This phase encouraged pupils to extend the concepts they had learned to make connections to other related concepts, and to apply their understandings to the world around them. The Researcher challenged the pupils to broaden and deepen their understanding of concepts and processes through additional activities. [24] indicated that pupils who still held misconceptions with their current ideas may be able to clarify their perceptions through this extension of learning. The pupils’ attempt to extend their newly structured knowledge to a deeper and broader understanding led to further inquiry and new understandings.

3.4.5. Evaluation Stage
This phase offered pupils the opportunity to assess their understanding and abilities, and also for researcher to monitor how pupils’ understandings had progressed. Information the researcher gained from evaluation served as a guide to the researcher in further lesson planning and indicated the need for modification and change of direction. In order to assess what students have learned and how much they have increased their knowledge about the topic introduced, a new activity in the same form was given to each group to work on. When each group completed the activity, they compared their answers with the other groups. The researcher then discussed the correct answers with the pupils for the them to realize their mistakes. At the same time, the pupils reached a conclusion about the topic by assessing new knowledge and skills in this phase.

3.4.6. Data Collection and Analysis
Data was collected during observation and from completed worksheets. Worksheets were checked for misconceptions and incorrect scientific ideas. The gains the pupils made through the activities in terms of correcting their incorrect ideas and formulating their conceptions were analyzed.

4. Results and Discussion

4.1. What Ideas do Pupils Bring to the Study of the Mixtures, Heredity, Osmosis, and Diffusion?

Data was collected from observation of classroom teaching sessions, from the group worksheet and also from class discussions with peers, with the researcher acting as a facilitator during the class discussions. The pupils held misconceptions and misinformation about the four concepts.
The pupils’ misconceptions are summarized in Table 1.
The lesson on diffusion begun with a number of ideas some of which were misconceptions. Pupils indicated one by the views they chose as a group in the cartoons given to them and two by the reasons they gave for their choice of cartoon view. A number of these ideas brought to the learning situation were verbal. Pupils debated the ideas of the cartoons before settling on one of the views. Some of them thought only the water molecules will move while the crystal molecules stayed where they were. These pupils explained that when one observed a water body one would realize that the water was always in motion while the other materials in the water remained where they were. Other pupils also held the view that both the water and crystal molecules will move all over the container. One pupil defined diffusion as “a chemical process which takes
place when the crystal is put in the water and changes the colour”. Another pupil also had this to say: “the crystal spreads through the water because water is partially permeable”. When asked what will be observed when cube sugar is dropped in water, one pupil gave this explanation: “both sugar molecules and water will move” he went further to explain that the sugar molecules will only move when the water molecules move. These were some of the misconceptions that hindered the pupils’ understanding of diffusion.

Table 1. Misconceptions pupils brought into the learning situation

<table>
<thead>
<tr>
<th>Topic</th>
<th>Pupils’ Misconceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffusion</td>
<td>Diffusion is a chemical process which takes place when the crystal is put in the water and changes the colour.</td>
</tr>
<tr>
<td></td>
<td>The crystal spreads through the water because water is partially permeable.</td>
</tr>
<tr>
<td></td>
<td>Both solute molecules and water will move.</td>
</tr>
<tr>
<td></td>
<td>Water molecules will move while the crystals stay where they were.</td>
</tr>
<tr>
<td>Osmosis</td>
<td>All living cells (plant and animal cells) will remain fresh and intact when kept in water for a long time.</td>
</tr>
<tr>
<td></td>
<td>Salt is so strong that it can even destroy saucepan when kept in it for a long time so it can kill cells in a vegetable within minutes.</td>
</tr>
<tr>
<td></td>
<td>Salt can cause fish to dry and can be preserved for months so it can kill the cells in the leaves.</td>
</tr>
<tr>
<td>Mixture</td>
<td>The salt melted in the water.</td>
</tr>
<tr>
<td></td>
<td>The water absorbed the salt.</td>
</tr>
<tr>
<td></td>
<td>A solution which said the salt killed the cells</td>
</tr>
<tr>
<td>Heredity</td>
<td>Children resemble people their mother was always when she was pregnant.</td>
</tr>
<tr>
<td></td>
<td>Albinism is a curse.</td>
</tr>
<tr>
<td></td>
<td>Albinism is caused by heat in the womb.</td>
</tr>
<tr>
<td></td>
<td>Children must have same blood groups as parents</td>
</tr>
<tr>
<td></td>
<td>When a pregnant woman touches her womb with a clay pot the part of the fetus the clay touched becomes as black as the pot.</td>
</tr>
</tbody>
</table>

Similar results were obtained when osmosis was treated. The pupils brought their own ideas to the learning situation. The pupils held the view that all living cells (plant and animal cells) will remain fresh and intact when kept in water for a long time. When asked why, they indicated that water has the ability of keeping things fresh. Pupils were asked how the water worked to keep the cells fresh. One pupil said “when you put something in water for example, a plant, it does not make it dry but rather fresh always”. The pupils were asked whether water entered the plant. One pupil said that “yes a little will enter but most of it stays around the plant to keep it well”. Few pupils agreed with the cartoon which said the salt killed the cells in the leaves whereas others agreed with the view that the salt became poison to the leaves. They gave the following reasons: “Salt is so strong that it can even destroy saucepan when kept in it for a long time so it can kill cells in a vegetable within minutes”. “Salt can cause fish to dry and can be preserved for months so it can kill the cells in the leaves”.

During the lesson on mixtures the pupils reasoned that a solution cannot be separated into its components since the solute disappeared in the water. Additionally, the pupils confused dissolution with melting. One pupil said “the salt melted in the water” another said “the water absorbed the salt”

On heredity, a number of misconceptions were held by the pupils. Among them were:

“Children take after people their mother was always with when she was pregnant”

“Albinism is a curse”

“Albinism is caused by heat in the womb”

“Children must have same blood groups as parents”

“When a pregnant woman touches her womb with a clay pot, the part of the fetus the clay touched becomes as black as the pot”

“A child who does not look like any of the parents might belong to another man outside the marriage”

Misconception also known as alternative conceptions or erroneous understanding are views or opinions that are incorrect based on inappropriate thinking. These alternative conceptions which can be shared or can be personal are significant and should not be disregarded as they are the basis on which other learning is constructed [1]. Misconceptions are extremely common in science and they are a normal part of the learning process due to the abstract nature of some of the concepts that are learned [3]. Misconceptions are extremely tough to change affecting learners’ understanding of scientific concepts simply because they are stable mental structures [25]. A misconception can come from a wide range of sources. Parents, folklore, teachers, multimedia and even learners trying to make sense of the world around them are responsible for cultivating these misconceptions. Ref. [26] found out that if a child does not have a concept in his mother tongue, he will find it difficult learning it in a second language. Faulty information from textbooks and science curricula are also responsible for perpetuating misconceptions. In spite of the many exertions to correct misconceptions, students continue to form their own explanations of science phenomena [27]. The misconceptions pupils brought to the learning of the concepts cut across four out of the five types of misconceptions outlined by the [29]. These are the categories of the misconceptions:

Preconceived notions which are popular conceptions rooted in everyday experiences include the following:

- All living cells (plant and animal cells) will remain fresh and intact when kept in water for a long.
- When you put something in water for example plant it does not make it dry but rather fresh always.
- Salt kills cells in leaves.
- Salt can be poisonous to leaves.
- Children must have same blood groups as parents.
- A child who does not look like any of the parents might belong to another man outside the marriage.
A number of conceptual misunderstandings are likely to arise when pupils learn scientific information in a way that does not incite them to challenge contradictions. Such situation was noticed as reported below:

- **Diffusion** is a chemical process which takes place when the crystal is put in the water and changes the colour.
- The crystal spreads through the water because water is partially permeable so the crystal was able to spread throughout the water.
- Both water and sugar molecules will move

Vernacular misconceptions arise from the use of words that have everyday meaning different from their scientific meanings. This is expressed in the following statement:

*The salt melted in the water.*

Nonscientific beliefs include views learned by pupils from sources other than scientific education, such as religious or cultural perspective. This is illustrated by the following explanations about albinism given by the pupils in this study:

- **Children take after people their mother was always with when she was pregnancy. Albinism is a curse.**
- **Albinism is caused by heat in the womb.**
- **When a pregnant woman touches her womb with a clay pot the part of the fetus the clay touched becomes as black as the pot.**

4.2. Will the use of Concept Cartoons through the 5E Instructional Model Diagnose and Correct Pupils’ Misconceptions on Mixtures, Heredity, Osmosis and Diffusion?

Data was collected from the experiments conducted by the pupils, group worksheet and also from class discussions with researcher and with peers.

Teaching science using concept cartoons adapted to the 5E instructional model was characterized by pupils constructing their own ideas based on their prior experiences through exploration. The concept cartoons allowed pupils to voice out their ideas which were corrected through activities they performed and through discussions. In confronting and addressing pupils’ misconceptions, new material (concept cartoons with worksheets) was given to pupils. They discussed the concept presented in the concept cartoon and designed their own experiments to confirm their predictions. Resources were provided for them to conduct their designed experiments. After the experiments they compared their results to the predictions they made at the engage phase. During the explanation phase the researcher brough out the pupils’ prior knowledge about the topics, had discussion with them based on the experiments they conducted. Pupils were then guided to look for the patterns of errors in the prior knowledge which were incorrect.

During class or group discussions, the pupils had the opportunity to compare their original ideas some which were misconception or incorrect scientific ideas with the ones in the cartoons. They also had opportunities to listen to their peers’ explanations about the correct science concept and built on their initial conceptual framework. They investigated and reinterpreted the ideas in the cartoons [28]. These enabled pupils to correct their misconceptions and constructed the correct science concepts actively in an interactive environment through concept-cartoon based instruction. The pupils had a misconception that the salt melted in the water. This misconception is a vernacular misconception because in their local language the same word is used for melting and dissolution. Pupils were able to rectify this misconception when they dissolved salt in water and melted shea butter with a high temperature. They realized that melting occurred when there is high temperature but dissolution occurs in a solvent. Pupils also had the misconception that albinism is caused by heat in the womb and also children must have the same blood group as their parents. The researcher at this stage helped the pupils to correct this misconception by taking them through genetic crossing. After the genetic crossing they understood the concept of inheritance of traits. Following the instructional model most of the pupils in the study reformulated their ideas and developed scientifically accurate conceptions of diffusion and osmosis and the other concepts treated. Understanding of the concepts were also developed by the pupils through their exploration activities and through the researcher led discussions. Through these pupils were able to relate their learning to everyday experiences.

To overcome misconceptions, the [29] suggested that teachers first detect these misconceptions, give learners opportunity to challenge them, and then guide them to restructure 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 should be realized by the learners identifying it as an irregularity. Teachers therefore, must offer learners opportunities for conceptual change through various activities [27].

During observation of the lessons before the intervention the researcher realized that most of the pupils did not have much opportunity to bring out their ideas. Only a few of them were able to express their ideas through questions and some answers they gave. The researcher noted that some of the pupils did not get the concepts clearly but science teacher failed to address pupils’ misconceptions appropriately, he told them what they were thinking were incorrect and did not occur as they thought. This then meant that what was on the minds of pupils remained as it was. If these ideas however, were unscientific pupils did not get the opportunity to correct them.

5. Conclusion

Concept cartoons can be used as a tool to elicit pupils’ prior ideas. This gives teachers an idea of the misconceptions pupils come to class with and their subsequent correction. A teacher who knows his or her pupils’ misconceptions can maximize their learning by using concept cartoon as a valuable tool that leads pupils to generate discussions and scientific investigations in order to gain in-depth knowledge into concepts and how things work; This way misconceptions can be corrected. It is therefore important to begin teaching with pupils’ experiences revealed through concept cartoons with 5Es
instructional Model to enable the pupils challenge their own views with the new insights that lead to conceptual change in order to bridge the gap between their preconceptions and new knowledge.

**Statement of Competing Interests**

The author has no competing interests.

**References**


Appendix

Worksheet for Presentation of Results During Experiment

Now look at the cartoon together. Discuss the statements of Kofi, Joe, Ama and Efua. Who do you think is right? Why do you think so? *We think that..........is right because.............*

**Set-up and design:** use words and a drawing to describe how you will conduct your experiment. Formulate it in a way that other children can replicate your experiment. *We will find out by...............................................

What do you expect to happen? *My experiment worked if I observe that..................

**Materials:** What do I need to conduct the experiment? Make a list of all the material you need ............................................................

**Results:** Describe what happened when you conducted the experiment: what did you see?

What did you measure? *I saw that.................................................................

**Conclusion:** Read again what you wrote at step 3. What did you find out doing this experiment? Did you expect this outcome? *Yes/no, because.....................

**Discussion:** Did things go wrong during the experiment? What things? What would you like to find out more about? *I wonder if.............................................................

Worksheet for presentation of results of activities

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