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DIAGNOSIS OF MISCONCEPTIONS IN BIOLOGY PART OF GENERAL SCIENCE BOOK: A CASE STUDY OF PRIMARY SCHOOL STUDENTS

Shazia Aziz[1]
PhD Scholar, Department of Educational Training
The Islamia University of Bahawalpur
shaziaazizchishtilhr@gmail.com

Muzammila Akram
Associate Professor, Department of Educational Training
The Islamia University of Bahawalpur
muzammila.akram@iub.edu.pk

ABSTRACT
True conceptualization is critical in understanding the fundamental principles of general science at the primary level. Concepts developed without prior understanding of the subject are not always wrong, although they might be characterized as misconceptions. The current study was conducted to identify misconceptions in biology part of general science book. Furthermore, it was to analyze the most likely causes of these diagnose misconceptions among primary school students. The current study was a case study. Two-tier diagnostic tests and diagnostic test interviews were employed as study instruments. The 400 fifth-grade students were chosen on purpose as a test sample, and 20 students were chosen for the semi-structured interview that possessed more misconceptions. Thematic analysis was utilized to do a qualitative study of the data. In addition, data triangulation was performed to combine the test and interview results. Language misunderstanding, misinterpretation of prior knowledge and visualization inaccuracy were the main causes for diagnosed misconceptions. It was recommended that a suitable atmosphere for general science learning be provided and that teachers should design learning using the appropriate method, strategy, model, and media to dispel misconceptions in biology part of general science book among primary school students.
Keywords: Misconception, general science, primary students, reasons behind misconceptions.

INTRODUCTION
Misconception is defined as a faulty thought, idea, notion, naive concept, erroneous notions, or misunderstanding. Such notions are infected by inaccurate belief, incorrect concept, assumption, naive idea, incorrect assumption, or misunderstanding. Such ideas are based on weak logic or erroneous facts. Misconceptions are beliefs held by students that differ from those held by the scientific community (Sungur et al., 2001).

Students usually establish their own beliefs as they learn about their surroundings, whether formally through school curricula or informally through their daily experiences. Several studies have been attempted to demonstrate pupils' learning as a result of this issue. The various types of student conceptions have been labeled as ‘alternative conceptions’ (Klammer, 1998; Wandersee et al., 1994), ‘misconceptions’ (Clement et al., 1989; Driver & Easley, 1978; Helm, 1980), ‘naive beliefs’ (Caramazza et al., 1980) and ‘conceptual difficulties’ (McDermott, 1993). Whatever it is called, the overarching purpose of nearly all of these studies is to understand wrong and defective conceptions that impede learning or to uncover helpful components of these flawed conceptions for usage in various settings. According to the National Research Council (1997), the primary role of misconceptions in science learning is a barrier for primary school students to learn basic concepts of science because misconceptions frequently prevent students from developing correct ideas that can be used as the initial insight for advanced learning.

Understanding the misconceptions that underpin science is essential for both teaching and understanding general science. Teachers must be aware of the conceptual challenges that their pupils confront when studying biology (Drechsler, 2007). However, simply presenting material and relying on unscientific students' attitudes and minds are ineffective methods of overcoming misconceptions; these factors, along with students' varying levels of background knowledge, educational and surrounding

[1] Corresponding Author

environment, prior experiences, teaching and learning materials used by teachers, textbooks, and world view, all have an impact on students' accurate interpretation of concepts (Cetingul & Geban, 2011).

Misconceptions are a regular and necessary part of the learning process (Jason et al., 2018). Students frequently make blunders when attempting to grasp basic biological principles. As a result, pupils are unable to assimilate new material offered in class and instead become even more confused and the subject of misunderstanding. According to Ulya Lathifa (2018), misunderstandings of basic ideas make it difficult for students to assimilate new content since they provide inaccurate descriptions of the concepts being studied. Students' ages, cultures, genders, places, and religious views, among other things, might influence the nature of the conceptual obstacles they experience in school (Losh et al., 2003).

Research studies explored, Learners nowadays are quite different from learners in the past; nevertheless, one thing they all have in common is misconceptions. There are incorrect conceptions that are regarded to be correct in every topic under debate. It's human nature to attempt to figure out how everything fits together. These thoughts will be made up of whatever gives us intellect. Everyone in our world creates his or her own predictions about how the world works; these are simple life puzzles. It is critical to remember that predictions are merely guesses, and it is not more than anyone uncove

ring a plan that attempts to clear up confusions. These are misconceptions that frequently lead to incorrect ideas.

Cummins (1984) investigated the causes of misconceptions and discovered that students typically focus on the first superficial sources that come to mind. The factual distortion they acquire from family, teachers, friends, print, and electronic media is one of these dynamics. Vygotsky (1978) suggested two explanations for the role of language in the formation of understanding: For starters, language provides a medium for learning. This suggests that learning occurs in a social setting, with social communication serving as the spirit of learning. Second, language is a tool that assists the learner in developing a way of thinking. According to Vygotsky (1978), kids understand when social experience is internalized. The learners transform the understanding at social level (inter psychological), and then at individual level (intra psychological). Vygotsky (1978) describes that students cannot understand without language and proper understandings of words.

Countries all over the world are investing in education to encourage creativity and technological skills in the next generation of citizens. This puts increased pressure on educators to dedicate more time and energy to improving the quality of scientific learning in the classroom (Morrison, Bartlett, & Raymond, 2009). When primary pupils attempt to comprehend scientific concepts and facts in biology, they frequently acquire misconceptions or alternative beliefs. These alternate concepts could pave the way for future alternative conceptions. Akram et al. (2014) investigated the elements that contributed to the development of misunderstandings among primary school children. These problems included a lack of information, misunderstanding of language, a lack of instructional aids, rote learning, overcrowded courses, and students' passive role. Bird and Welford (1995) discovered a significant disparity between British school learners and second language learners. In comparison, second language students performed poorly in science examinations. Akram (2016) and Sayer (2013) explored that language misunderstanding is an important factor that causes misconceptions among primary students and urged future research in Pakistan to analyze the role of language in misconceptions. As a result, the current study was developed to identify misconceptions and to explore the best probable reasons behind the misconceptions in learning biology at primary level.

Objectives of the Study

Objectives of the study were:

1. To investigate the misconceptions in learning the biological part of general science at primary school level.
2. To explore the best possible reasons behind the misconceptions in learning the Biological part of general science at primary school level.

MATERIALS AND METHODS

The present study adopted a case study design because researcher collected qualitative data about a problem. The targeted population was all primary 5th grade students enrolled in Government primary schools, middle schools and high schools in district Bahawalnagar. Four hundred learners were selected randomly. In this study, two-tier diagnostic test and semi structured interview were used as tools. Five expert science teachers validated the test. A test was utilized to identify primary school students' misconception in biology part of general science book. The diagnostic test consisted of eight (8) multiple-

choice questions (MCQs). The diagnostic test was developed with the help of a fifth-grade general science textbook. Punjab Text Board Lahore produced this general science book in edition (2019-2020). The MCQs questions in diagnostic test were developed in view of the misconceptions of learning general science, which were mentioned in the earlier researches. Thematic analysis was used to assess the qualitative data that was collected. After that twenty (20) students of 5th grade who possessed more misconceptions were selected purposively for diagnostic test interview. To prepare the diagnostic test, the researcher selected some specific topics from this Punjab text book i.e. classification of living things and microorganisms. It was created by the researcher while keeping the study's objectives in mind.

Table 1. Table of content

No. of units	Names of Units	No. of Pages
1	Classification of living things	1
2	Micro- organisms	18

Source: Punjab Curriculum Authority, Punjab Text Book, Lahore (2019-2020)

The above Table 1 mentioned list of general science textbook content was taught in all public schools in Punjab province in the 5th grade. Chapters 1and 2 were from biology part of general science book of 5th grade.

RESULTS AND DATA ANALYSIS

In order to identify students' misconceptions about the selected concepts or themes, a two tier diagnostic test was given to the 5th grade students chosen from randomly selected schools during the 2020-2021 academic years. After taking the data obtained from this test into account, the semi structured test interviews from the selected students were conducted to explore the reasons behind these diagnosed biology misconceptions. Students' responses to the items are provided below in the form of tables to diagnose student's biology misconceptions and to explore the reasons behind them in biology part of general science book among primary school students.

Item No. 1: Whales and Dolphins are belongs to the group of:

A Fish B Amphibians C* Mammals D Reptiles

Table 2. Distribution of Students' Answers among the Options for Item 1

Options	A	B	C*	D	Uncodeable	Total students
Frequency	215	0	176	0	9	400
Percentage	53.8%	0	44%	0	2.3%	

According to Table 2, 44% of students correctly answered this question while 56% erroneously answered it. This table revealed that the majority of primary students did not have a firm grasp of the subject and majority of the students hold misconceptions about this question. The reasons for these misconceptions and the rationale of the students' answers were probed further through an interview. As a result, 20 students were interviewed using a semi-structured diagnostic test interview to determine the best potential reasons for these beliefs. Students were asked to justify their responses during the interview. As an example,

R: Why did you choose option A?

S1: Because I saw a movie about whales and dolphins on TV and they looked just like other fish. So I choose this alternative.

R: Can you explain your response?

S1: Yes, whales and dolphins live in water (rivers and lakes) like other fish, and by structure, whales and dolphins appear to be fish. That is why I chose this choice (whales and dolphins belong to the group of fish).

Another student explained why she gave her answer in this manner:

S2: In daily speech, people frequently associate the word "Fish" with whales and dolphins, as in Dolphin Fish or Whale Fish. That is why I believe whales and dolphins are members of the Fish group.

Following this debate, it can be concluded that the most likely causes of these misconceptions are misinterpretation of their prior knowledge about the topic and language confusion (regarding the word "Fish").

Item No. 2 Lizard belongs to which group of animals?

A Amphibians B* Reptiles C Birds D Mammals

Table 3. Distribution of Students' Answers among the Options for Item 2

Options	A	B*	C	D	Uncodeable	Total students
Frequency	127	273	0	0	0	400
Percentage	31.8%	68.3%	0	0	0	

According to Table 3 showed that 68.3% of students correctly answered question 2, whereas 31.8% erroneously answered it. As a result, it is clear that the majority of pupils grasp this issue. While 31.8% of students gave erroneous answers to this item, they clearly had a misperception. An interview was conducted to go deeper into the causes of these beliefs. As a result, 20 students were questioned and asked to justify their responses. As an example,

R: Why did you choose option A as your answer? Do you have any explanation for your response?

S1: Yes, I did see a picture of a large lizard in my textbook (p.8, pic.1.9). Salamanders, according to our teacher, are members of the amphibian family. I assumed it was a large lizard. That is why I chose this choice.

S2: My older sister once showed me a large lizard (crocodile) that lived in both water and on land on television. So I assumed that both the huge lizard (crocodile) and the small lizard are amphibians.

Some pupils reported finding parallels between lizards, crocodiles, and salamanders, such as brown skin, egg lying, and the fact that all of these species are cold blooded, and then assuming reptiles are also amphibians. Their structures appeared to be identical. With the discussion, it is possible to conclude that the most likely reasons of these misunderstandings are misinterpretation of prior information and visualization inaccuracy.

Item No. 3: Fish breathe through?

A Lung B Skin C* Gills D Mouth

Table 4. Distribution of Students' Answers among the Options for Item 3

Options	**A**	**B**	**C***	**D**	**Uncodeable**	**Total Students**
Frequency	201	15	168	16	0	400
Percentage	50.3%	3.8%	42%	4%	0	

According to this Table 4, 42% of students correctly answered question 3 whereas 58% erroneously answered it. As a result, we might conclude that the majority of students hold misconceptions about Item 3. The researcher conducted semi-structured interviews with 20 students to determine the best potential reasons for these misconceptions. Students justified their responses during the interview. Laiba, for example, defended her response as follows

R: Why did you choose lungs as organ of breathing fish?

S1: Because, I thought, fish breathe through their lungs.

R: Did you have a valid reason for this thought?

S1: Fish, like humans, is a living entity that breathes through its lungs. Fish, like humans, breathe through their lungs. So I believe fish breathe through their mouths.

S3: My older brother once taught her that frogs can survive in water and breathe through their damp skin. So I assumed fish lived in water also so like frogs, breathed via their skin.

During the interview, it was discovered that the majority of students were perplexed about the functions and structure of gills and lungs, therefore students were requested to imagine the structure and function of lungs and gills and draw their diagrams to alleviate their confusion. It might be stated that the best likely reasons for these misconceptions are misinterpretation of prior information and visualization inaccuracy.

Item 4: Worms and insects are belong to

A Vertebrate group B* Invertebrate group C Reptile group D Amphibians group

Table 5. Distribution of Students' Answers among the Options for Item 4

Options	A	B*	C	D	Uncodeable	Total students
Frequency	182	107	111	0	0	400
Percentage	45.5%	26.8%	27.8%	0	0	

According to the following Table 5, 26.8% of students correctly answered the question, whereas 73.3% erroneously answered it. It was clear that the majority of pupils' grasp of this topic was hazy. As a

result, they undoubtedly had misconceptions. Twenty students (20) were interviewed to determine the most likely causes of these beliefs. Students justified their responses during the interview. For example, they explained their responses (A) as follows:

R: Are you certain that worms and insects are classified as vertebrates? If so why?

S1: Worms and insects have backbones. Like a result, their bodies appeared hard, as in cockroaches.

Another student who chose option "c" explained her decision as follows:

S2: I actually observed an earthworm and a cockroach. They crawled around on the ground. As a result, I assumed they belonged to the reptile family.

Following this discussion, it became evident that students have legitimate reasons for holding these opinions. As a result of the discussion, it is possible that the best plausible reasons for these misconceptions are visualization inaccuracy and language misunderstanding.

Item No 5: Virus, bacteria and fungi are the group of

A* Group of microorganisms B Group of reptiles C Group of invertebrate animal D Group of birds

Table 6. Distribution of Students' Answers among the Options for Item 5

Options	A*	B	C	D	Uncodeable	Total students
Frequency	359	7	34	0	0	400
Percentage	89.8%	1.7%	8.5%	0	0	

According to this Table 6, 89.8% of students correctly answered the question, while 10.2% erroneously answered it. It was clear that the majority of students had a good comprehension of the subject. While 10.2% of students gave erroneous answers, they clearly had misperceptions. The researcher used semi-structured diagnostic test interviews with the (20) students to investigate the most likely causes of the identified misconceptions. When asked to justify their answer during the interview, they stated their thoughts as follow:

R: What made you select option B (reptile)?

S1: When I looked at viruses, bacteria, and fungi via a microscope, they appeared to be very small animals that crawled like reptiles. As a result, I believe they are reptiles and choose option B.

S2: I saw virus, bacteria, and fungi diagrams in my book. They appear to be soft and flexible. As a result, I believe they lacked a backbone and belonged to the invertebrate animal group.

This conversation revealed that pupils had a few unreasonable motives for developing these misunderstandings. Students were perplexed since their understanding regarding germs and reptiles were unclear. With this discussion, it is feasible to conclude that the best plausible explanation for these diagnosed misconceptions was the misunderstanding of terms (microorganisms and reptile) and visualization inaccuracy.

Item No 6: Some micro-organisms that decompose the dead bodies are called

A Herbivores B Producers C Consumers D* Decomposers

Table 7. Distribution of Students' Answers among the Options for Item 6

Options	A	B	C	D*	Uncodeable	Total students
Frequency	0	214	0	170	16	400
Percentage	0	53.5%	0	42.5%	4%	

According to the Table 7, 42.5% of students correctly answered the question, while 53.5% erroneously replied. It was clear that the majority of pupils' grasp of this topic was hazy. As a result, they undoubtedly had misconceptions. An interview was conducted to go deeper into the causes for these misconceptions and the reasoning behind the students' responses. To achieve this goal, the semi-structured diagnostic test interview was conducted with 20 students to investigate the most likely causes of these misconceptions. When asked to justify their answers during the interview, the students responded in the following manner:

R: Why did you select the option B?

S1: I'm aware that these microbes turn dead carcasses into something useful, such as fertilizers. As a result, these creatures are known as producers since they make new compounds.

R: Where do you get your information about microorganisms?

S1: My grandfather once told my older brother that some microorganisms decompose animal carcasses into substances that increase land fertility. I had also heard this

During the interview, it can be analyzed that students were not fully aware about terms (producers, decomposers, herbivores and consumers). With this discussion, it became apparent that students have illogical reasons to develop these misconceptions. So, it can be analyzed that the best possible reasons behind these misconceptions might be the misinterpretation of prior knowledge and language confusion.

Item No 7: The bodies of all the living things are made up of very small units called:

A* Cells B Tissues C Bricks D Cell wall

Table 8. Distribution of Students' Answers among the Options for Item 7

Options	**A***	**B**	**C**	**D**	**Uncodeable**	**Total students**
Frequency	180	220	0	0	0	400
Percentage	45%	55%	0	0	0	

According to the Table 8, 45% of students answered correctly, while 55% answered incorrectly. It was clear that the majority of students' understanding of this topic was hazy. So, they definitely possessed misconceptions. The researcher conducted semi-structured diagnostic test interviews with (20) students to investigate the best possible reasons for the diagnosed misconceptions. When students were asked to justify their chosen comments during the interview, they did so in the following manner:

R: Why did you choose the option B? Have you any reason for this selection?

S: According to my textbook, tissue is a group of cells that collaborate to execute various functions in the body. So, I believe that the bodies of living creatures are made up of these tissues, and that the body performs all of its duties efficiently with the assistance of these tissues. Furthermore, I'm not sure what the word "unit" means in this question.

During the diagnostic test interview, it was discovered that the majority of students were perplexed and stated that they did not comprehend the distinction between the terms cells and tissues (misunderstanding of terms). Following this discussion, it was conclude that the most likely cause of this misunderstanding of language (confusion between scientific term cells and tissues) and an ineffective teaching style.

Item No 8 Virus can be seen with the help of:

A Eye B Magnifying glass C Light microscope D* Electron microscope

Table 9. Distribution of Students' Answers among the Options for Item 8

Options	A	B	C	D*	Uncodeable	Total students
Frequency	0	0	228	172	0	400
Percentage	0	0	575%	43%	0	

According to this Table 9, 43% of students correctly answered the item, while 57% erroneously answered the item. It was clear that the majority of pupils' grasp of this topic was hazy. They were unaware of the distinction between a light microscope and an electron microscope. As a result, they undoubtedly had misconceptions. An interview was conducted to go deeper into the causes for these misconceptions and the reasoning behind the students' responses. To achieve this goal, the researcher performed semi-structured diagnostic test interviews with 20 students in order to investigate the most likely causes of these beliefs. When students were asked to justify their responses (c) during the interview, they did so in the following manner:

S1: I learned in my fourth-grade textbook that microorganisms can only be viewed under a microscope and not with the naked eye. I know that viruses are also microorganism that is why we can view them with a simple microscope.

Following this explanation, it is possible to conclude that the most likely cause of this misconception is a misunderstanding of language (light microscope and electron microscope). This misperception evolved among the pupils as a result of insufficient explanation of the topic.

Table 10. Frequency of student's responses to reasons of misconceptions

Item No.	Language misunderstanding	Misinterpretation of prior knowledge	Visualization Error	Uncodeable Responses
1	**20**	**20**	**0**	**0**
2	**0**	**30**	**10**	**0**
3	**0**	**28**	**12**	**0**
4	**18**	**0**	**22**	**0**
5	**39**	**0**	**0**	**1**
6	**20**	**19**	**0**	**1**
7	**40**	**0**	**0**	**0**
8	**39**	**0**	**0**	**1**
Total	**176**	**97**	**44**	**3**
%age	**55%**	**30.32%**	**13.75%**	**.93%**

Best Possible Causes behind Misconceptions

Statements about misconceptions put before students during semi-structured interview. All expected information from learners' accepting of misconceptions and associated concepts were collected with the help of recorded questions related to their answers to core questions. It was asked to learners to give detail and justification about their answers. During interviews, learners' answers of question were recorded, judged and organized in categories and themes were developed. This study demonstrated how learners form misconceptions. This study intended to establish a logical link between knowledge provided to students, and as a result, students created misconceptions. After analysis of responses, three major causes were explored. Language misunderstanding was the first major reason, while misinterpretation of prior knowledge considered second main reason and Visualization error proved the third main reason behind the diagnosed misconceptions in biology part of general science book of 5th grade (Table 9).

CONCLUSION

The results of this study showed that 5th grade students had various misconceptions in learning biology part of general science book. There are various types of misconceptions due to different causes. Many misconceptions were gained by students studying general science topics at the primary level. These ideas could be the consequence of earlier experience, ordinary language, or prior study. The most possible reason for primary school students' misconceptions in biology was misunderstanding of language. Sometimes language confusion was caused by misunderstanding of general vocabulary and sometimes due to misunderstanding of specific scientific terms and words. One problem is that English is the second or occasionally third language of all Pakistani pupils. When they attempted to comprehend the statements, they translated them into Urdu, resulting in misunderstanding. Furthermore, incorrect word usage resulted in language misunderstanding. Cassels and Johnstone (1980) discovered that non-technical words linked with science were a source of confusion for pupils. Both Garnett and Treagust (1992) and Ogude and Bradley (1998) noted that incorrect language used to convey science topics is a key source of misconceptions, and this study is no exception. The majority of primary-level science pupils lacked the capacity to utilize suitable scientific vocabulary. They frequently utilized inaccurate terminology such as classification, electron microscope, decomposers, producers, cells, tissues, evaporation, acid rain, and so on. Misinterpretation of prior knowledge was the second main causes of biological misconceptions in general science among primary school students.

Misinterpretation of prior knowledge referred to when students misunderstand the subject. Students could not interpret new material using such static and erroneous prior knowledge. For example, in response to item (1), Ali misinterpreted of prior knowledge of breathing organs of living things such as fish, resulting in the formation of misconceptions such as (1) fish breathes through lungs like humans (2) fish breathes through skins like frogs because both live in water. Students expanded their ideas in general science to the particulate level of representation. When developing mental models for abstract concepts in science, these overgeneralizations are not unique to science (Morris, 2008). It was discovered that external visualization errors generated visualization misconceptions, which were called Visualization Error. For example, improper labeling of textbook diagrams and improper classification of various organisms via diagrams caused visualization errors. The visualization error of student's answers supported in the discovery of previously unreported general science misconceptions. The current study's findings confirmed Nakhleh's (1992) and Ozmen's (2004) findings that previous misconceptions caused further

misconceptions. During learning, students attempted to integrate new information into their cognitive structure. If they had misconceptions, these would impede their subsequent learning. As a result, new knowledge could not be linked to their existing structure, and the concept was misunderstood (Nakhleh, 1992; Ozmen, 2004).

RECOMMENDATIONS

Based on the problem and the findings of the analysis of the discussion conducted, the researcher recommends:

1. The current study was conducted at the primary school level. More study at the elementary school and higher secondary levels is required.
2. Considering the corpus of misconceptions research, additional study should be conducted at the secondary school level in diagnosing misunderstandings and their causes in mathematics and basic science courses such as physics, biology, and computer science.
3. The teacher must be able to recognize students' misconceptions as soon as feasible.
4. Teacher should design learning with the right approach, strategy, model, and media to minimize the existence of misconception.

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