Evaluating Teacher's Understanding of Science Concepts

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Abstract

The purpose of this study was to investigate the level of awareness of elementary school teachers regarding biological misconceptions related to the systems of the human body in the 5th grade science curriculum in Kuwait's public elementary schools. The study was conducted with 60 teachers who taught at least one section of the 5th grade science curriculum during the last four years. The Biological Misconception Survey, which consisted of 15 statements, was used to identify the teachers' misconceptions prior to workshop instruction about misconceptions in biological concepts. The survey statements were grouped into categories about the function of systems of the human body. The teachers' answers were evaluated based on a rubric of four levels, assessing their scientific accuracy, level of expression, and logical reasoning. The study revealed many misconceptions and lack of clarity among teachers in Kuwait's public elementary schools, indicating problematic issues concerning the teaching of biological concepts. The findings suggest that this study could help in identifying or developing strategies to reduce or eliminate such misconceptions and implement these strategies at the appropriate level of students' cognitive development.

Keywords: *Misconceptions – Science Education – Rubric – Professional development*

1. Background

Misconceptions are common in science education, and it is critical to identify and address them to improve students' learning outcomes. Several studies have been conducted on the identification of misconceptions among science students, teachers, and the general public. Misconceptions are common in science education, and several studies have investigated their nature and prevalence among students and teachers. These studies highlight the importance of identifying and addressing misconceptions in science education to promote conceptual change and improve learning outcomes. Lombardi and Sinatra (2014) explored the role of scientific explanations in correcting misconceptions in evolution education. The They highlighted the importance of addressing misconceptions through effective scientific explanations that are based on evidence and reasoning. They also suggested that scientific explanations that provide an understanding of the natural world are essential in correcting misconceptions and promoting conceptual change. The second article by Kucharská and Hodásová (2017) investigated the misconceptions of primary school students about the human digestive system. The study used a multiple-choice diagnostic test to identify common misconceptions among the students. The researchers found that most of the students had a limited understanding of the digestive system and had several misconceptions. The study highlights the importance of identifying and addressing misconceptions in science education at an early age. Another article by Demirbas and Senocak (2016) investigated the misconceptions of pre-service science teachers about the nature of science. The researchers found that most of the pre-service teachers had several misconceptions about the nature of science, including its objectivity and its relationship with religion. The study suggested the need for targeted professional development programs to address these misconceptions.

1.1 Purpose

Background Science education plays a crucial role in preparing students for future careers and fostering scientific literacy. However, misconceptions are pervasive in science education and can impede students' understanding and application of scientific concepts. Identifying and addressing misconceptions is essential to enhance learning outcomes and promote conceptual change.

1.2 Significance of the Study

This study addresses the need to assess and address misconceptions among science teachers, as they play a pivotal role in shaping students' scientific understanding. By evaluating teachers' justifications for their responses to open-ended questions, this study aims to gain insights into the nature of misconceptions and inform targeted interventions in science education.

1.3 Research Objectives

The primary objectives of this study are: a) To assess science teachers' justifications for their responses to open-ended questions related to common misconceptions. b) To identify patterns and trends in the misconceptions expressed by science teachers. c) To provide recommendations for addressing misconceptions in science education.

2. Method

2.1 Participants

The participants in this study were teachers who had experience teaching science subjects at various grade levels. A purposive sampling technique was used to select a diverse group of teachers to ensure a representative sample.

2.2 Instrument

A survey instrument was developed to collect data on teacher responses to open-ended questions related to common misconceptions in science. The survey consisted of several questions requiring teachers to provide explanations or justifications for their responses. The questions were designed to elicit a range of misconceptions commonly found in science education.

2.3 Rubric Development

A rubric, known as the Misconception Justification Rubric, was developed based on the coding approach described by previous researchers (Demirbas & Senocak, 2016). The rubric consisted of four criteria: scientific accuracy, logical reasoning, clarity of expression, and overall quality. Each criterion had four levels of performance, ranging from Level 4 (high) to Level 0 (insufficient or no response). The rubric provided clear descriptions for each level to ensure consistent scoring.

2.4 Rubric Application

Two independent raters, trained in the use of the Misconception Justification Rubric, evaluated the teacher responses. Each rater independently assessed the responses based on the rubric criteria and assigned a score for each criterion. To ensure inter-rater reliability, a subset of responses was randomly selected and scored by both raters. Any discrepancies in scoring were discussed and resolved through consensus.

2.5 Data Analysis

The scores assigned by the raters were compiled and entered into a spreadsheet for analysis. Descriptive statistics, such as mean and standard deviation, were calculated for each criterion and overall score. The qualitative data, including the teacher responses and the raters' comments, were analyzed thematically to identify patterns and trends in the justifications provided by the teachers.

2.6 Findings and Interpretation

The quantitative analysis provided an overview of the overall quality of the teacher responses, highlighting areas of strength and areas for improvement. The qualitative analysis helped to deepen the understanding of the misconceptions and the underlying reasoning behind the justifications provided by the teachers. The findings were interpreted in light of the research objectives and relevant literature, providing insights into the teachers' understanding of misconceptions in science education.

2.7 Limitations

It is important to acknowledge the limitations of this study. The sample size may limit the generalizability of the findings to a larger population. Additionally, the use of a rubric for evaluation introduces subjectivity, despite efforts to establish inter-rater reliability. The reliance on self-reported justifications from teachers may also introduce biases or incomplete understanding of the misconceptions.

Table1. Rubric for Assessing Justifications for Misconceptions in Science

Criteria	Level 4	Level 3	Level 2	Level 1	Level 0
Scientific Accuracy	Responses demonstrate a clear and accurate understanding of scientific concepts and principles, and accurately identify the cause of the misconception.	Responses demonstrate a mostly accurate understanding of scientific concepts and principles, and mostly accurately identify the cause of the misconception.	Responses demonstrate a partially accurate understanding of scientific concepts and principles, partially accurately identify the cause of the misconception.	Responses demonstrate an inaccurate understanding of scientific concepts and principles, and inaccurately identify the cause of the misconception.	Insufficient or no response: The response is blank, off-topic, or otherwise insufficient to assess.
Logical Reasoning	Responses demonstrate clear and logical reasoning, with well-supported arguments for the cause of the misconception.	Responses demonstrate mostly clear and logical reasoning, with mostly well-supported arguments for the cause of the misconception.	Responses demonstrate partially clear and logical reasoning, with partially well-supported arguments for the cause of the misconception.	Responses demonstrate unclear or illogical reasoning, with unsupported arguments for the cause of the misconception.	Insufficient or no response: The response is blank, off-topic, or otherwise insufficient to assess.
Clarity of Expression	Responses are clear and concise, with effective use of scientific vocabulary and terminology.	Responses are mostly clear and concise, with mostly effective use of scientific vocabulary and terminology.	Responses are partially clear and concise, with partially effective use of scientific vocabulary and terminology.	Responses are unclear or verbose, with ineffective use of scientific vocabulary and terminology.	Insufficient or no response: The response is blank, off-topic, or otherwise insufficient to assess.
Overall Quality	Responses demonstrate a high level of scientific accuracy, logical reasoning, and clarity of expression.	Responses demonstrate a mostly high level of scientific accuracy, logical reasoning, and clarity of expression.	Responses demonstrate a partially high level of scientific accuracy, logical reasoning, and clarity of expression.	Responses demonstrate a low level of scientific accuracy, logical reasoning, and clarity of expression.	Insufficient or no response: The response is blank, off-topic, or otherwise insufficient to assess.
Total grade	12	9	6	3	0

This rubric could be used to assess the justifications provided by teachers for their answers to open-ended questions on a survey about misconceptions in science. The criteria are based on the coding approach described earlier, with each level representing a different level of accuracy, reasoning, and expression.

3. Results

Based on the provided responses from the teachers, it is evident that there are misconceptions among science teachers regarding certain scientific concepts. The rubric for assessing justifications allows us to analyze these responses and identify the nature and prevalence of these misconceptions. Using a qualitative method, we can delve into the responses and identify patterns and trends in the misconceptions expressed by the teachers.
Scientific Accuracy: Many of the responses demonstrate a lack of accurate understanding of scientific concepts and principles. For example, teachers responded that we need oxygen in vital processes and digestion (8) or that when we exhale, water droplets are formed (5). These responses indicate misconceptions about the role of oxygen in vital processes and the nature of exhaled air.
Logical Reasoning: The logical reasoning exhibited in the responses also indicates misconceptions among the teachers. Some responses, such as "because the air contains oxygen, which humans inhale and exhale carbon dioxide" (2), or "the human body cannot take any gas except O2" (2), show flawed reasoning in understanding the exchange of gases in respiration.
Clarity of Expression: In terms of clarity of expression, several responses lack effective use of scientific vocabulary and terminology. For instance, responses like "the body needs energy and food and oxygen" (8) or "cells need oxygen" (2) demonstrate a lack of precise and scientific language in expressing the concepts.
Overall Quality: Overall, the responses indicate a low level of scientific accuracy, logical reasoning, and clarity of expression. Many teachers provided incomplete or incorrect explanations that suggest a lack of understanding or misconceptions regarding respiration and the structure of the human body.
Based on this analysis, it is clear that there are misconceptions among the science teachers in various aspects of science. These misconceptions can hinder effective teaching and student learning. It highlights the importance of targeted professional development programs that address these misconceptions and provide accurate scientific explanations and understanding. By addressing these misconceptions, teachers can enhance their own understanding and consequently improve the quality of science education in Kuwait.

4. Conclusion and Implications

The implications of the findings for science education are discussed, emphasizing the need for targeted interventions to address misconceptions among teachers. The importance of professional development programs and curriculum enhancements for teachers.

Based on this analysis, it is clear that there are misconceptions among the science teachers in various aspects of science. These misconceptions can hinder effective teaching and student learning. It highlights the importance of targeted professional development programs that address these misconceptions and provide accurate scientific explanations and understanding. By addressing these misconceptions, teachers can enhance their own understanding and consequently improve the quality of science education in Kuwait.

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