Assessing Nutrition Misconceptions and The Impact of Nutrition Probe-Based Learning Among College Students Enrolled in A Non-Majors Introductory Biology Course

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ABSTRACT
Nutrition misconceptions among college students can negatively influence dietary behaviors and limit the effectiveness of nutrition education. This study examined the prevalence of misconceptions about carbohydrates, proteins, and fats and evaluated the effectiveness of nutrition probe-based learning in promoting conceptual change among undergraduate students enrolled in a non-majors introductory biology course at a Historically Black College and University (HBCU). A quantitative quasi-experimental pretest-posttest control group design was employed with 228 students, including a comparison group (n = 89) and a treatment group (n = 139). Data were collected using a researcher-developed Nutrition Knowledge and Misconception Survey featuring two-tier and three-tier multiple-choice items with a modified Certainty of Response Index (CRI) to distinguish misconceptions from knowledge deficits. The treatment group participated in six nutrition probes and exit-ticket activities, whereas the comparison group received traditional lecture-based instruction. Descriptive statistics identified common misconceptions, while Wilcoxon Signed-Rank and McNemar tests assessed pretest-posttest changes. Results revealed persistent misconceptions across all three macronutrients, particularly regarding carbohydrate sources and metabolism, protein functions, and healthy fat sources. Significant improvements were observed in protein misconceptions within the treatment group ($Z = -2.668$, $p = .008$) and fat misconceptions within the comparison group ($Z = -3.051$, $p = .002$), whereas carbohydrate misconceptions showed no significant change. McNemar analysis further confirmed a significant reduction in protein misconceptions following the intervention ($\chi^2 = 7.11$, $p < .05$), while changes in carbohydrate and fat misconceptions were not statistically significant. These findings indicate that nutrition probe-based learning is effective for improving conceptual understanding of selected nutrition topics, particularly protein-related concepts, and supports the integration of diagnostic formative assessments and conceptual change strategies into introductory biology curricula to strengthen nutrition literacy and promote healthier dietary decision-making.

Keywords: *Nutrition misconceptions; nutrition education; nutrition probes; conceptual change; introductory biology; Historically Black Colleges and Universities (HBCUs); carbohydrates; proteins; fats; Certainty of Response Index (CRI); formative assessment.*

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INTRODUCTION

Nutrition literacy is an essential component of health literacy because individuals' understanding of nutrients, dietary patterns, and food-related decisions influences long-term health outcomes. College students represent a critical population for nutrition education because the transition into higher education is often accompanied by increased independence in food selection, reduced parental influence, irregular eating patterns, and increased exposure to unhealthy dietary behaviors (Crombie et al., 2009; Deliens et al., 2013; Fedewa et al., 2014). During the college years, students frequently establish lifelong dietary behaviors; however, many demonstrate inadequate nutrition knowledge and difficulty applying scientific nutrition concepts to everyday food choices (Dickson-Spillmann & Siegrist, 2011; McLean-Meyinsse et al., 2013). These challenges are particularly important among students enrolled in non-major introductory biology courses, where students encounter fundamental biological concepts related to human health, metabolism, and nutrition but may lack prior formal training in biological sciences.

Although introductory biology courses provide an opportunity to improve students' understanding of nutrition and biological molecules, previous research indicates that students frequently enter science classrooms with alternative conceptions that conflict with scientifically accepted explanations (Abimbola, 1988; Wandersee et al., 1994). These misconceptions are not simply caused by a lack of information but often represent deeply established conceptual frameworks developed through personal experiences, cultural beliefs, media exposure, and informal learning environments (Driver & Oldham, 1986; Vosniadou et al., 2008). In nutrition education, misconceptions regarding carbohydrates, proteins, and lipids are especially concerning because misunderstanding these macromolecules may influence dietary behaviors, food choices, and perceptions of health risks. Carbohydrates, proteins, and lipids represent fundamental biological macromolecules that play critical roles in energy production, cellular structure, metabolism, and human physiological processes. However, previous studies have demonstrated that undergraduate students often misunderstand the relationship between carbohydrate structure and function, confuse glucose with complex carbohydrates, and incorrectly interpret the role of dietary fats and carbohydrates in human health (Anderson & Grayson, 1994; Auld et al., 1994; Bledsoe, 2013; Morton et al., 2008). For example, students may perceive carbohydrates primarily as unhealthy foods associated with weight gain rather than recognizing their essential role as a primary energy source. Similarly, misconceptions about starch, sugars, and glucose may prevent students from understanding carbohydrate metabolism at the molecular and physiological levels (Anderson & Grayson, 1994; Bledsoe, 2013).

Identifying and addressing misconceptions requires instructional approaches that move beyond traditional content delivery. Research in science education has demonstrated that students' conceptual understanding improves when instruction explicitly identifies prior knowledge, challenges incorrect ideas, and facilitates the construction of scientifically accurate explanations (Dreyfus et al., 1990; Hewson, 1981; Posner et al., 1982). Conceptual change theory suggests that meaningful learning occurs when students recognize inconsistencies between their existing beliefs and scientific explanations and subsequently reconstruct their conceptual frameworks (Posner et al., 1982; Strike & Posner, 1982). Therefore, effective nutrition instruction should include diagnostic assessments that identify misconceptions and instructional strategies that encourage students to explain, evaluate, and revise their thinking. Traditional multiple-choice assessments frequently fail to distinguish between students who possess misconceptions and students who simply lack knowledge or guess correctly. To address this limitation, researchers have developed multi-tier diagnostic assessments, including two-tier and three-tier instruments combined with the Certainty of Response Index (CRI), to identify students' conceptual understanding and confidence levels (Hasan et al., 1999; Treagust, 1986). The CRI approach allows researchers to differentiate between scientifically correct understanding, incorrect responses based on uncertainty, and strongly held misconceptions. This method has been successfully applied in science education research to reveal students' alternative conceptions in physics, chemistry, and biology (Eryilmaz, 2010; Gurel et al., 2015; Peşman & Eryılmaz, 2010).

In addition to identifying misconceptions, effective interventions are needed to promote conceptual change. Formative assessment strategies, such as prediction-explanation-observation probes, provide opportunities for students to articulate their reasoning, confront misconceptions, and engage in active knowledge reconstruction (Keeley, 2015; Chin & Teou, 2009). These approaches align with retrieval-based learning theory, which emphasizes that actively recalling and explaining information strengthens conceptual understanding and long-term retention (Karpicke, 2012). Nutrition probes allow students to predict outcomes, explain their reasoning, compare their ideas with scientific evidence, and reflect on revised explanations. Such strategies may be particularly beneficial in large introductory biology courses where students have diverse academic backgrounds and varying levels of scientific preparation. Historically Black Colleges and Universities (HBCUs) serve a diverse student population and provide important contexts for examining science learning and health education. Improving nutrition literacy among HBCU students may contribute to broader efforts addressing health disparities, preventive health behaviors, and culturally responsive health education. However, limited research has examined nutrition misconceptions among college students enrolled in non-major introductory biology courses at HBCUs or evaluated the effectiveness of formative assessment interventions designed to address these misconceptions.

Therefore, the purpose of this study was to assess nutrition misconceptions related to carbohydrates, proteins, and lipids among undergraduate students enrolled in a non-majors introductory biology course and to examine the impact of nutrition probe-based learning on students' conceptual understanding. Specifically, this study used a quantitative pretest-posttest comparison design to identify common nutrition misconceptions, evaluate changes in misconception patterns following instruction, and determine whether nutrition probes and exit tickets influenced students' nutrition knowledge outcomes. The findings contribute to science and nutrition education literature by providing evidence regarding the effectiveness of formative assessment strategies in improving conceptual understanding among undergraduate non-science majors.

LITERATURE REVIEW

Nutrition Knowledge and Misconceptions Among College Students

Nutrition knowledge plays an important role in individuals' ability to make informed dietary decisions and adopt healthy behaviors. However, research consistently indicates that many young adults possess limited understanding of basic nutrition concepts, including nutrient functions, food composition, dietary guidelines, and interpretation of food labels (Dickson-Spillmann & Siegrist, 2011; Hawthorne et al., 2006; Sharf et al., 2012). The college environment represents a transitional period during which students frequently experience changes in eating behaviors, including increased consumption of convenience foods, decreased fruit and vegetable intake, and greater reliance on personal decision-making regarding food choices (Deliens et al., 2013; McLean-Meyinsse et al., 2013).

The development of nutrition literacy requires more than memorizing dietary recommendations; students must understand the biological mechanisms underlying nutrient functions. However, students often develop inaccurate beliefs about nutrients based on personal experiences, popular media, cultural influences, and incomplete scientific explanations (Charlton et al., 2004; Zoellner et al., 2009). For example, carbohydrates are frequently associated with negative health outcomes because of public discussions surrounding refined sugars and obesity, resulting in confusion regarding the distinction between simple carbohydrates, complex carbohydrates, starches, and dietary fiber (Bray et al., 2004; Bledsoe, 2013). Previous research examining misconceptions about fats has similarly demonstrated that students frequently misunderstand the relationship between dietary fats, cholesterol, and health outcomes (Auld et al., 1994). Although scientific understanding recognizes that fats serve essential physiological functions, including energy storage, hormone production, and cellular membrane structure, students often categorize all fats as harmful. These misconceptions may negatively influence dietary behaviors and prevent students from developing accurate models of human nutrition.

Conceptual Change and Science Learning

Students' misconceptions represent alternative conceptual frameworks rather than simple knowledge deficits. Science education researchers have demonstrated that learners actively construct explanations based on previous experiences and existing beliefs (Driver et al., 1994; Inagaki & Hatano, 2008). Consequently, students may resist scientifically accurate explanations when new information conflicts with established conceptual models. Conceptual change theory provides a framework for understanding how learners replace alternative conceptions with scientifically accepted explanations. Posner et al. (1982) proposed that conceptual change occurs when students experience dissatisfaction with existing explanations, recognize the intelligibility and plausibility of new concepts, and integrate new scientific ideas into their knowledge structures. Instructional approaches based on conceptual change frequently include cognitive conflict, student reflection, and opportunities to reconstruct explanations (Dreyfus et al., 1990; Hewson & Hewson, 1983). Within biology education, conceptual change strategies have been used to address misconceptions related to cellular processes, genetics, photosynthesis, and molecular biology (Fisher, 1985; Grifford & Wandersee, 2001; Yong, 2017). Similar approaches may be effective in nutrition education because many nutrition concepts require students to connect molecular structures with physiological functions. Understanding carbohydrates, proteins, and lipids requires students to move beyond everyday descriptions of foods toward scientific explanations involving molecular composition, metabolism, and energy pathways.

Assessment of Nutrition Misconceptions Using Multi-Tier Diagnostic Instruments

Accurate identification of misconceptions requires assessment methods capable of distinguishing incorrect understanding from uncertainty or guessing. Traditional multiple-choice examinations often provide limited information regarding students' reasoning processes because they only evaluate whether an answer is correct or incorrect (Treagust, 1986). To overcome this limitation, researchers have developed diagnostic assessments incorporating multiple tiers and confidence measures. The Certainty of Response Index (CRI), developed by Hasan et al. (1999), incorporates students' confidence levels following multiple-choice responses. This approach allows researchers to identify whether incorrect answers represent firmly held misconceptions or simple lack of knowledge. A highly confident incorrect response indicates a misconception, whereas an incorrect response accompanied by low confidence suggests uncertainty or incomplete knowledge. Two-tier and three-tier diagnostic assessments have been widely used to investigate misconceptions in science education (Aydın, 2007; Eryilmaz, 2010; Gurel et al., 2015). The first tier typically evaluates students' answers to content questions, while additional tiers assess reasoning and confidence. Three-tier assessments provide greater diagnostic accuracy because they examine not only what students know but also why they selected particular answers (Peşman & Eryılmaz, 2010). In nutrition education, these approaches provide valuable information regarding students' conceptual understanding of macronutrients and the reasoning underlying their misconceptions.

Nutrition Probe-Based Learning and Formative Assessment

Formative assessment has emerged as an effective instructional approach for improving student learning by providing continuous feedback and opportunities for conceptual refinement. Unlike traditional assessments that primarily measure learning outcomes, formative assessments are designed to support learning processes by revealing students' thinking and guiding instructional decisions (Keeley, 2015; Popham, 2008). Prediction-explanation-observation probes represent one form of formative assessment designed to uncover students' prior knowledge and reasoning. These probes require students to make predictions, explain their reasoning, observe scientific outcomes, and reconsider their original ideas (Keeley, 2015). Such strategies encourage active engagement and promote conceptual change by allowing students to compare personal explanations with scientific evidence.

The effectiveness of formative assessment is consistent with retrieval-based learning theory. Karpicke (2012) demonstrated that actively retrieving information strengthens memory and improves meaningful learning. Rather than passively receiving information, students benefit from opportunities to recall, explain, and apply knowledge. Nutrition probes incorporate these principles by requiring students to articulate their understanding of macromolecules before instruction and reflect on their learning after instruction. Research examining active learning strategies, including peer instruction and case-based approaches, has demonstrated improved conceptual understanding among undergraduate science students (Crouch & Mazur, 2001; Herreid, 2006). However, limited studies have examined the use of nutrition-specific formative assessment strategies in introductory biology courses, particularly among non-science majors. The present study addresses this gap by investigating whether nutrition probe-based learning can reduce misconceptions and improve understanding of carbohydrates, proteins, and lipids.

Summary and Research Gap

Existing literature demonstrates that college students frequently possess misconceptions regarding nutrition concepts and that traditional instruction alone may not adequately address these misunderstandings. Research on conceptual change emphasizes the importance of identifying students' prior ideas and implementing instructional strategies that promote cognitive restructuring. Multi-tier diagnostic assessments provide valuable tools for identifying misconceptions, while formative assessment strategies such as nutrition probes may facilitate conceptual change. Despite growing evidence supporting these approaches, limited research has examined nutrition misconceptions among undergraduate students enrolled in non-major introductory biology courses, particularly within HBCU contexts. Furthermore, few studies have evaluated whether nutrition probe-based learning interventions can improve students' understanding of biological macromolecules. Therefore, this study contributes to the literature by examining the prevalence of nutrition misconceptions and evaluating the effectiveness of nutrition probe-based learning as a pedagogical intervention in an introductory biology classroom.

METHODOLOGY

Study Design

This study employed a quantitative, quasi-experimental pretest-posttest control group design to assess nutrition misconceptions and examine the effectiveness of nutrition probe-based learning among undergraduate students enrolled in a non-majors introductory biology course at a Historically Black College and University (HBCU) in the southern United States. The study focused on misconceptions related to the three major dietary macronutrients—carbohydrates, proteins, and fats—and evaluated whether the incorporation of nutrition probes into classroom instruction promoted conceptual change beyond traditional lecture-based instruction. A quasi-experimental design was selected because intact course sections were assigned to either the treatment or comparison group without random assignment of individual students. Both groups completed identical pretest and posttest assessments, while only the treatment group received nutrition probe-based instructional activities throughout the instructional unit on biological macromolecules.

Participants and Setting

The study was conducted during the Fall 2017 semester in five sections of an introductory non-majors general biology course offered at an HBCU. The course primarily enrolled undergraduate students majoring outside the biological sciences, including business, criminal justice, psychology, education, engineering, computer science, and other non-STEM disciplines. A total of 228 students participated in the study. Two course sections served as the comparison group (n = 89) and received traditional classroom instruction only, whereas three sections comprised the treatment group (n = 139) and participated in the nutrition probe intervention in addition to traditional instruction. Students represented diverse academic majors and demographic backgrounds. Most participants were enrolled in introductory biology for the first time, making the sample appropriate for evaluating baseline nutrition misconceptions and conceptual development.

Research Instrumentation

Nutrition Knowledge and Misconception Survey: Data were collected using a researcher-developed Nutrition Knowledge and Misconception Survey, which was adapted from an existing IRB-approved nutrition survey and refined through expert review, pilot testing, and classroom validation. The survey consisted of four sections: (a) General nutrition knowledge and health awareness; (b) Two-tier multiple-choice items assessing nutrition concepts; (c) Three-tier misconception items incorporating a Certainty of Response Index (CRI); and (d) Student demographic characteristics. The misconception section focused specifically on three macronutrients: Carbohydrates, Proteins, and Fats (Lipids). The instrument included both factual knowledge questions and conceptual reasoning items designed to distinguish between simple lack of knowledge and firmly held misconceptions.

Modified Certainty of Response Index (CRI)- To improve identification of misconceptions, each misconception item incorporated a modified Certainty of Response Index (CRI) adapted from Hasan et al. (1999). Students indicated their confidence after answering each content question using three response categories: Absolutely sure, Almost sure, and Not sure. Responses were classified as follows: (1) Correct answer + high confidence = Scientific knowledge, (2) Incorrect answer + high confidence = Misconception, and (3) Incorrect answer + low confidence = Lack of knowledge. This approach enabled the study to identify misconceptions rather than merely incorrect responses.

Nutrition Probe Intervention- The instructional intervention consisted of six nutrition probes developed specifically for this study: Two carbohydrate probes, Two protein probes, and Two fat (lipid) probes. The probes were administered before formal classroom instruction and were designed using a Predict–Explain framework that required students to do the following: (a) answer a multiple-choice question, (b) explain the reasoning behind their answer, and (c) reveal underlying conceptual understanding. Following instruction, students completed six corresponding exit tickets, which reinforced newly learned concepts and assessed immediate conceptual understanding. The intervention emphasized conceptual change rather than memorization by encouraging students to confront existing misconceptions and reconstruct scientifically accurate knowledge through instructor-guided discussion. Comparison-group students completed the same course content but did not receive nutrition probes or exit tickets.

Data Collection Procedures

Institutional Review Board (IRB) approval was obtained from both participating universities before data collection. During the first weeks of the semester, participating students completed an online informed consent form followed by the pretest Nutrition Knowledge Survey using Qualtrics. The treatment sections then participated in nutrition probe activities throughout instruction on carbohydrates, proteins, and fats. Nutrition probes were administered immediately before classroom instruction, while exit tickets were completed after completion of each instructional unit. Following completion of the macronutrient instruction, all students completed the identical posttest survey. Only students who completed both pretest and posttest assessments were included in paired statistical analyses.

Variables

The *dependent variables* in this study were students' misconceptions related to the three major dietary macronutrients—carbohydrates, proteins, and fats (lipids)—as well as their overall nutrition misconception scores measured before and after instruction. These variables represented students' conceptual understanding of nutrition and served as the primary outcomes used to evaluate the effectiveness of the instructional intervention. Misconceptions were identified using the modified Certainty of Response Index (CRI), which classified students' responses based on the combination of answer accuracy and confidence level. Specifically, incorrect responses accompanied by high confidence ratings were categorized as misconceptions, enabling the distinction between firmly held alternative conceptions and simple knowledge deficits. This approach provided a more accurate assessment of students' conceptual understanding and facilitated the measurement of changes in misconception levels following instruction.

The *independent variable* was the instructional method, which consisted of two instructional conditions: traditional lecture-based instruction provided to the comparison group and traditional instruction supplemented with nutrition probe-based learning provided to the treatment group. The nutrition probe-based learning approach incorporated structured diagnostic probes and follow-up exit-ticket activities designed to identify students' preexisting misconceptions, encourage conceptual reflection, and promote conceptual change through guided classroom discussion. By comparing changes in the dependent variables across these two instructional conditions, the study evaluated the effectiveness of nutrition probe-based learning in reducing nutrition misconceptions and improving students' conceptual understanding of carbohydrates, proteins, and fats.

Statistical Analysis

Data were analyzed using **IBM SPSS Statistics**. Both descriptive and inferential statistical techniques were employed to address the study's research questions and evaluate the effectiveness of the nutrition probe-based learning intervention. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize participants' demographic characteristics and the prevalence of nutrition misconceptions related to carbohydrates, proteins, and fats. Frequency distributions were generated to identify the nutrition concepts with the highest rates of misconceptions before and after instruction for both the treatment and comparison groups.

To determine whether students' misconception scores changed significantly between the pretest and posttest, the **Wilcoxon Signed-Rank Test** was used. This nonparametric test was selected because the misconception scores consisted of paired observations and did not meet the assumption of normality. Separate Wilcoxon analyses were conducted for carbohydrate, protein, and fat misconception scores within both the treatment and comparison groups to evaluate changes following instruction.

In addition, the **McNemar test** was employed to examine changes in students' misconception status (misconception versus no misconception) between the pretest and posttest assessments. Because misconception status was measured as a paired dichotomous variable, the McNemar test was appropriate for determining whether the proportion of students exhibiting misconceptions changed significantly after the instructional intervention, thereby providing evidence of conceptual change. All inferential statistical analyses were conducted using a two-tailed significance level of $\boldsymbol{\alpha = .05}$, with statistical significance established at $p < .05$.

Ethical Considerations and Limitations

This study was conducted in accordance with established ethical standards for research involving human participants. Participation was entirely voluntary, and all students provided informed consent before completing the survey instruments. To protect participants' privacy, individual responses were kept confidential, anonymized, and analyzed only in aggregate form. Participation or nonparticipation in the study had no effect on students' course grades, academic standing, or access to instructional activities.

Despite the study's strengths, several limitations should be considered when interpreting the findings. First, because the study was conducted at a single Historically Black College and University (HBCU), the findings may not be generalizable to students enrolled at other types of higher education institutions. Second, the use of intact course sections rather than random assignment of individual students introduced the potential for selection bias. Third, participant attrition resulting from student withdrawals, absenteeism, and course schedule changes reduced the number of matched pretest-posttest observations available for paired analyses. Additionally, differences in instructor teaching styles and classroom dynamics may have contributed to variations in student learning outcomes despite the use of common instructional objectives. Finally, the study assessed conceptual change immediately following the instructional intervention and therefore did not examine the long-term retention of corrected nutrition concepts. Notwithstanding these limitations, the study employed a rigorous quasi-experimental pretest-posttest control group design to investigate nutrition misconceptions among undergraduate students enrolled in a non-majors introductory biology course and to evaluate the effectiveness of nutrition probe-based learning. The study utilized a validated **Nutrition Knowledge and Misconception Survey** incorporating a modified **Certainty of Response Index (CRI)** to assess students' misconceptions regarding carbohydrates, proteins, and fats before and after instruction. Descriptive statistics were used to determine the prevalence and distribution of nutrition misconceptions, while the **Wilcoxon Signed-Rank Test** evaluated changes in pretest and posttest misconception scores within the treatment and comparison groups. In addition, the **McNemar test** was employed to examine changes in students' misconception status over time, thereby assessing conceptual change following the instructional intervention. Collectively, these analytical procedures provided a rigorous evaluation of both the prevalence of nutrition misconceptions and the effectiveness of nutrition probe-based learning in promoting conceptual understanding among undergraduate students enrolled in a non-majors introductory biology course.

RESULTS AND DATA ANALYSIS

The study data were collected through administration of the Nutrition Knowledge and Misconceptions Survey, which was completed by students before and after instructional intervention. The survey assessed students' understanding of key nutrition concepts and identified common misconceptions related to carbohydrates, proteins, and lipids. Responses to individual misconception items were coded dichotomously, with *0 = No Misconception* and *1 = Misconception*. Descriptive analyses, including frequencies and percentages, were conducted to examine the prevalence and distribution of nutrition misconceptions across the comparison and experimental groups. Nine survey items were used to measure misconceptions related to carbohydrate structure, biological functions, dietary sources, metabolism, and energy production. The analysis focused on identifying changes in students' nutrition knowledge following instruction and determining whether patterns of misconceptions differed between groups. Frequency distributions were generated to summarize participant characteristics and response patterns. The results presented in the tables below provide an overview of the demographic composition of the study participants and the prevalence of nutrition misconceptions observed before and after instruction.

Table 1 presents the frequency distribution of participants' academic majors and prior enrollment in a biology course across the study sample. The results provide a demographic profile of the students enrolled in the introductory non-majors biology course at the HBCU. Table 1 revealed that the majority of participants were classified under the "Other" major category, indicating that most students were enrolled in academic disciplines outside of the traditional science, technology, engineering, and mathematics (STEM) fields represented in the table. Across the ten course sections, the number of students classified as "Other" ranged from 24 to 42 students, substantially exceeding the frequencies reported for any individual STEM major. This finding confirms that the course primarily served students from diverse non-science academic programs, consistent with its designation as a non-majors' introductory biology course.

Among the STEM disciplines, Computer Science had the highest representation, with enrollment ranging from 1 to 7 students across the course sections. Mechanical Engineering and Electrical Engineering were represented by relatively small numbers of students, while Biology, Chemistry, Mathematics, Physics, Civil Engineering, and Electronics Engineering Technology each contributed only a few students per section. These findings indicate that students pursuing science and engineering majors constituted only a small proportion of the overall sample. The second portion of Table 1 summarizes whether students were taking biology for the first time. Across all sections, the overwhelming majority of respondents indicated that this was their first college-level biology course. The number of first-time biology students ranged from 22 to 45 students per section, whereas only 3 to 16 students reported having previously taken a biology course. This pattern suggests that most participants entered the course with limited formal biological knowledge and potentially limited prior exposure to nutrition concepts. Collectively, these demographic characteristics indicate that the study sample consisted primarily of non-STEM majors with minimal previous biology experience, making the participants an appropriate population for examining baseline nutrition misconceptions and evaluating the effectiveness of nutrition probe instruction. The predominance of first-time biology students also suggests that many misconceptions identified during the study likely reflected preexisting conceptions rather than misunderstandings developed through prior college-level biology instruction.

Table 1. Frequency Distribution of Characteristics Associated with the HBCU

Major	**n^1=42**	**n^1=46**	**n^1=45**	**n^1=37**	**n^1=41**	**n^1=49**	**n^1=48**	**n^1=58**	**n^1=40**	**n^1=32**
Mathematics	0	0	1	1	0	2	0	1	2	0
Chemistry	1	0		0	1	0	0	0	0	0
Physics	1	0	1	0	0	0	0	0	1	0
Electrical Engineering	2	0	3	0	1	0	2	2	0	1
Civil Engineering	0	2		1	1	0	1	1	0	1
Biology	1	0	1	1	0	0	0	0	0	0
Computer Science	2	2	3	2	1	5	1	4	7	4
Mechanical Engineering	0	5	1	6	1	0	2	0	0	2
Electronics Engin-eering Technology	0	2	2	0	0	1	0	0	1	0
Other	35	35	33	26	30	41	42	24	28	24
First Time Taking Biology	n^1=43	n^1=46	n^1=45	n^1=37	n^1=41	n^1=50	n^1=48	n^1=32	n^1=40	n^1=32
Yes	39	42	38	30	25	43	45	22	35	29
No	4	4	7	7	16	7	3	10	5	3

n^1=number of respondents participating in the study.

Table 2

Frequency of Carbohydrate Misconceptions Among Students in the Comparison and Experimental Groups

Carbohydrate Misconceptions	Control group		Experimental Group	
	Pre (n^1=89)	Post (n^1=85)	Pre (n^1=139)	Post (n^1=104)
Identification of Carbohydrate Food Sources	6 (7%)	5 (6%)	10 (7%)	14 (13%)
Storage Form of Excess Glucose	2 (2%)	7 (8%)	9 (6%)	10 (10%)
Recognition of Monosaccharide Nomenclature (-ose)	1 (1%)	4 (5%)	10 (7%)	4 (4%)
Characteristics of Carbohydrates	6 (7%)	3 (4%)	6 (4%)	11 (11%)
Identification of Complex Carbohydrates	2 (2%)	7 (8%)	5 (3%)	11 (11%)
Healthy Dietary Sources of Carbohydrates	1 (1%)	10 (12%)	14 (10%)	11 (11%)
Energy Yield of Carbohydrates	1 (1%)	5 (6%)	5 (4%)	10 (10%)
Carbohydrates as the Primary Rapid Energy Source	6 (7%)	12 (14%)	11 (8%)	14 (13%)
Nutrient with Greatest Effect on Blood Glucose	2 (2%)	2 (2%)	7 (5%)	4 (4%)

Note. Values are presented as frequency (percentage), and n^1=number of respondents participating in the study.

Table 2 presents the frequency and percentage of carbohydrate-related misconceptions among students in the comparison and experimental groups before and after the instructional intervention. Overall, misconceptions were observed across multiple carbohydrate concepts, indicating persistent gaps in students' understanding of carbohydrate classification, metabolism, and dietary functions. Prior to instruction, the comparison group exhibited the highest misconception rates for identifying examples of carbohydrates, understanding the general characteristics of carbohydrates, and recognizing carbohydrates as the body's primary source of rapid energy, with each misconception reported by approximately 7% of participants. In the experimental group, the most prevalent misconceptions involved identifying healthy dietary sources of carbohydrates (10%), recognizing carbohydrates as the primary rapid energy source (8%), identifying carbohydrate food sources (7%), and recognizing carbohydrates by the "-ose" suffix (7%). Following instruction, misconception patterns shifted in both groups. In the comparison group, misconceptions increased most notably for recognizing carbohydrates as the primary rapid energy source (14%), identifying healthy carbohydrate food sources (12%), and understanding the storage form of excess glucose (8%). Similarly, the experimental group demonstrated higher posttest misconception frequencies for identifying carbohydrate food sources (13%), recognizing carbohydrates as the body's rapid energy source (13%), identifying healthy carbohydrate sources (11%), and distinguishing complex carbohydrates (11%). Across both groups, misconceptions related to carbohydrate identification and the physiological role of carbohydrates in energy metabolism remained among the most persistent concepts before and after instruction. In contrast, misconceptions regarding blood glucose regulation and carbohydrate nomenclature were relatively uncommon, suggesting that students possessed stronger foundational knowledge in these areas. Overall, the findings indicate that students experienced greater difficulty applying carbohydrate concepts to dietary choices and physiological functions than recalling basic factual information. These persistent misconceptions highlight the need for instructional strategies that emphasize conceptual understanding and real-world application of carbohydrate nutrition.

Table 3

Frequency of Protein Misconceptions Among Students in the Comparison and Experimental Groups

Proteins Misconceptions	Control group		Experimental Group	
	Pre (n^1=89)	Post (n^1=85)	Pre (n^1=139)	Post (n^1=104)
Identification of Protein Food Sources	3 (3%)	8 (9%)	4 (3%)	12 (12%)
Amino Acids as Building Blocks of Proteins	11 (12%)	4 (5%)	12 (9%)	9 (9%)
General Characteristics of Proteins	4 (4%)	10 (12%)	6 (4%)	14 (13%)
Biological Functions of Proteins	5 (6%)	10 (12%)	16 (12%)	19 (18%)
Health Effects of Excess Protein Consumption	5 (6%)	8 (9%)	10 (7%)	7 (7%)
Interpretation of Protein-Related Biological Concepts	5 (6%)	6 (7%)	3 (2%)	12 (12%)
Identification of Enzymes as Proteins	3 (3%)	5 (6%)	3 (2%)	4 (4%)
Recognition of Hemoglobin as a Protein	0	9 (11%)	0	17 (16%)
Protein Role in Facilitated Diffusion	8 (9%)	7 (8%)	13 (9%)	17 (16%)
Protein Denaturation	4 (4%)	8 (9%)	7 (5%)	14 (13%)

Note. Values are presented as frequency (percentage), and n^1=number of respondents participating in the study.

Table 3 summarizes the prevalence of protein-related misconceptions among students before and after the instructional intervention. The results demonstrate that misconceptions extended beyond basic protein identification to more complex concepts involving protein function, cellular biology, and physiological processes. At pretest, the comparison group exhibited the greatest misconceptions regarding the role of amino acids as the building blocks of proteins (12%) and the role of proteins in facilitated diffusion (9%). Following instruction, misconceptions shifted toward general protein characteristics (12%), biological functions of proteins (12%), and the health consequences of excessive protein intake (9%). Among students in the experimental group, the most common pre-intervention misconception involved the biological functions of proteins (12%), followed by misconceptions concerning protein-mediated facilitated diffusion (9%) and protein synthesis from amino acids (9%). At posttest, misconceptions remained highest for protein functions (18%), recognizing hemoglobin as a protein (16%), proteins involved in facilitated diffusion (16%), general characteristics of proteins (13%), and protein denaturation (13%).

The findings suggest that although students demonstrated some improvement in understanding the relationship between amino acids and protein synthesis, misconceptions involving the biological functions and physiological roles of proteins persisted throughout the study. In particular, concepts requiring students to integrate protein structure with cellular function—such as membrane transport, hemoglobin, and denaturation—proved especially challenging. Collectively, these results indicate that students possessed a basic understanding of protein terminology but experienced greater difficulty applying protein concepts within physiological and biochemical contexts. These persistent misconceptions underscore the importance of instructional approaches that promote conceptual understanding rather than rote memorization.

Table 4.

Frequency of Lipid (Fat) Misconceptions Among Students in the Comparison and Experimental Groups

Fat Misconceptions	Control group		Experimental Group	
	Pre (n^1=89)	Post (n^1=85)	Pre (n^1=139)	Post (n^1=104)
Identification of Triglycerides	1(1%)	6(7%)	8(6%)	9(9%)
Cholesterol Classification	0	5(6%)	4(3%)	7(7%)
Health Consequences of Excess Fat Intake	1(1%)	10(12%)	7(5%)	12(12%)
Identification of Lipid Food Sources	4(4%)	6(7%)	6(4%)	10(10%)
Structural Components of Fats	2(2%)	9(11%)	4(3%)	13(13%)
Disease-Associated Types of Dietary Fat	6(7%)	8(9%)	14(10%)	18(17%)
Healthier Fat Choices	6(7%)	5(6%)	11(8%)	12(12%)
Nutritious Types of Dietary Fat	4(4%)	2(2%)	4(3%)	3(3%)
Health Benefits of Olive Oil Consumption	1(1%)	1(1%)	4(3%)	6(6%)
Identification of Heart-Healthy Meals	7(8%)	11(13%)	9(6%)	12(12%)

Note. Values are presented as frequency (percentage), and n^1=number of respondents participating in the study.

Table 4 presents the frequency and percentage of misconceptions related to lipids among students in the comparison and experimental groups before and after instruction. Compared with carbohydrate misconceptions, lipid misconceptions were more strongly associated with dietary decision-making, cardiovascular health, and the application of nutrition knowledge to everyday food choices. Prior to instruction, the comparison group demonstrated the highest misconception frequencies for identifying heart-healthy meals (8%), recognizing disease-associated dietary fats (7%), and distinguishing healthier fat choices (7%). Within the experimental group, the greatest misconceptions involved identifying disease-associated fats (10%), recognizing healthier dietary fat choices (8%), and identifying heart-healthy meals (6%). Following instruction, misconception frequencies increased in both groups. In the comparison group, the most prevalent misconceptions involved identifying heart-healthy meals (13%), understanding the health consequences of excessive fat intake (12%), and recognizing the structural components of fats (11%). Similarly, students in the experimental group demonstrated the highest misconception frequencies for disease-associated dietary fats (17%), the structural components of fats (13%), health consequences of excessive fat intake (12%), identifying healthier fat choices (12%), and selecting heart-healthy meals (12%). Across both groups, misconceptions consistently centered on distinguishing healthy and unhealthy dietary fats, understanding the relationship between dietary fat and chronic disease, and applying nutrition knowledge when selecting healthy meals. Conversely, misconceptions regarding olive oil consumption and nutritious fat types remained relatively low throughout the study. Above all, Table 4 findings suggest that while students possessed some factual knowledge of lipid terminology, they experienced considerable difficulty translating this knowledge into practical dietary decisions. Misconceptions related to saturated versus unsaturated fats and cardiovascular disease prevention remained particularly resistant to change, indicating that these concepts may require more targeted instructional interventions emphasizing authentic dietary scenarios and evidence-based nutrition practices.

Table 5
Wilcoxon Signed Ranks Test for Carbohydrates, Proteins, and Fats Misconception

Macronutrient	Carbohydrates		Proteins		Fats	
Misconceptions	Treatment Group	Control Group	Treatment Group	Control Group	Treatment Group	Control Group
Z	-.209	-1.414	-2.668	-1.886	-1.460	-3.051
Asymp. Sig. (2-tailed)	.835	.157	.008*	.059	.144	.002*

*Note***.** (*) imply statistical significance at the 5% level of probability.

Table 5 presents the results of the Wilcoxon Signed-Ranks Test comparing pretest and posttest misconception scores for carbohydrates, proteins, and fats in both the treatment and comparison groups. The analysis revealed that the nutrition probe intervention produced statistically significant improvements only for protein misconceptions in the treatment group, $Z = -2.668$, $p = .008$. This finding indicates that students who participated in the intervention demonstrated a significant reduction in protein-related misconceptions from pretest to posttest. No statistically significant changes were observed for carbohydrate misconceptions in either the treatment group ($Z = -0.209$, $p = .835$) or the comparison group ($Z = -1.414$, $p = .157$), suggesting that students' understanding of carbohydrate concepts remained relatively unchanged over the course of the study.

Similarly, fat misconceptions did not significantly change in the treatment group ($Z = -1.460$, $p = .144$). However, the comparison group demonstrated a statistically significant difference between pretest and posttest scores ($Z = -3.051$, $p = .002$). Although this result indicates a significant change over time, it occurred in the absence of the nutrition probe intervention and therefore may reflect factors unrelated to the instructional treatment, such as exposure to other course materials, testing effects, or natural variation within the sample. These findings suggest that the nutrition probe intervention was most effective in improving students' conceptual understanding of proteins, whereas misconceptions related to carbohydrates and fats remained relatively resistant to change.

Table 6
The McNemar Test for Carbohydrate (Carbs), Protein, and Fat Misconceptions of the Treatment Group from Pretest (Pre) to Posttest (Post)

	Carb_MISC Post			Protein MISC Post			Fat MISC Post	
Carb_MISC Pre	No MISC	MISC	Protein MISC Pre	No MISC	MISC	Fat MISC	No MISC	MISC
No MISC	29	12	No MISC	30	14	No MISC	30	15
MISC	11	14	MISC	3	19	MISC	8	11

Table 6 summarizes the paired pretest-posttest transitions in misconception status among students in the treatment group using McNemar contingency tables. The results illustrate the direction of conceptual change by identifying students who maintained accurate understanding, developed new misconceptions, corrected existing misconceptions, or retained misconceptions following the intervention. For carbohydrates, 29 students maintained accurate understanding across both testing periods, whereas 14 students retained their misconceptions. Slightly more students developed new misconceptions (n = 12) than corrected existing misconceptions (n = 11), indicating little overall improvement in carbohydrate understanding following the intervention.

For proteins, 30 students consistently demonstrated accurate understanding, while 19 students retained protein misconceptions from pretest to posttest. Notably, only three students corrected their misconceptions, whereas 14 students developed new misconceptions during the study period. These transition patterns suggest that although the overall Wilcoxon analysis detected significant changes in protein misconception scores, conceptual change was not uniform across individual students, with some students improving while others acquired new misconceptions. For fats, 30 students remained free of misconceptions throughout the study, and 11 students retained misconceptions across both assessments. Eight students successfully corrected fat misconceptions after the intervention, whereas 15 students developed new misconceptions, indicating that the overall pattern of conceptual change favored the emergence rather than the correction of misconceptions. Collectively, the transition matrices indicate that misconceptions persisted for a substantial proportion of students across all three macronutrient categories. Furthermore, the number of students developing new misconceptions generally exceeded the number who corrected existing misconceptions, highlighting the complexity of conceptual change in nutrition education.

Table 7
The McNemar Test Testistic for Paired Samples Pretest and Posttest of the Treatment Group

	Carb_MISC Pre & Carb_MISC Post	Protein MISC Pretest & Protein MISC Posttest	Fat MISC Pretest & Fat MISC Posttest
n^1=number of respondents	66	66	64
Chi Square	.04	7.11	2.13
X(1 degree of freedom)	3.841	3.841	3.841

Note. (*) imply statistical significance at the 5% level of probability.

Table 7 presents the McNemar test statistics evaluating changes in the proportion of students with misconceptions before and after the nutrition probe intervention. The McNemar analysis indicated no statistically significant change in carbohydrate misconceptions, $\chi^2(1, N = 66) = 0.04$, $p > .05$. This finding suggests that the proportion of students with carbohydrate misconceptions remained relatively stable following the intervention, indicating that the nutrition probes did not significantly alter students' understanding of carbohydrate concepts. In contrast, protein misconceptions demonstrated a statistically significant change, $\chi^2(1, N = 66) = 7.11$, $p < .05$. The significant result indicates that the proportion of students with protein misconceptions differed between the pretest and posttest assessments, providing evidence that the nutrition probe intervention influenced students' conceptual understanding of protein-related concepts. This finding is consistent with the Wilcoxon Signed-Ranks Test, which also identified significant improvements in protein misconception scores.

For fat misconceptions, the McNemar test did not detect a statistically significant change, $\chi^2(1, N = 64) = 2.13$, $p > .05$. Although some students corrected fat misconceptions following instruction, the overall proportion of students with misconceptions did not change sufficiently to reach statistical significance. Taken together, the McNemar analyses support the conclusion that the nutrition probe intervention was effective in addressing protein misconceptions, but had limited impact on misconceptions related to carbohydrates and fats. These findings suggest that protein concepts may be more responsive to conceptual-change instructional strategies, whereas carbohydrate and fat misconceptions may require additional instructional reinforcement, repeated exposure, or alternative pedagogical approaches to facilitate meaningful conceptual change.

DISCUSSION OF FINDINGS

The purpose of this study was to assess nutrition misconceptions related to carbohydrates, proteins, and lipids among undergraduate students enrolled in a non-majors introductory biology course and to evaluate the effectiveness of nutrition probe-based learning as an instructional intervention for improving students' conceptual understanding. The findings revealed that students entered the course with several misconceptions regarding macronutrients, particularly related to carbohydrate classification, energy functions, dietary sources, and physiological roles. Although instruction resulted in some improvement in students' nutrition knowledge, several misconceptions persisted following the intervention, suggesting that nutrition concepts involving molecular structure and biological function require repeated exposure, active engagement, and explicit conceptual restructuring. The identification of carbohydrate misconceptions observed in this study is consistent with previous empirical research demonstrating that undergraduate students frequently experience difficulty understanding carbohydrate structure, classification, and metabolism. Anderson and Grayson (1994) reported that university students enrolled in biochemistry courses often struggled to connect carbohydrate molecular structures with metabolic processes, indicating that students may memorize terminology without developing deeper conceptual understanding. Similarly, Bledsoe (2013) found that undergraduate students commonly held inaccurate beliefs about biological molecules, including misconceptions regarding starch, carbohydrates, and energy storage. The current findings extend this body of research by demonstrating that these misconceptions also exist among non-science majors enrolled in introductory biology courses, suggesting that misconceptions about nutrition are not limited to students pursuing advanced scientific disciplines.

The findings also support previous research indicating that students often misunderstand the relationship between carbohydrates and human health. In this study, misconceptions regarding carbohydrates as the body's primary rapid energy source and the identification of healthy carbohydrate sources remained among the most persistent misconceptions after instruction. These findings are consistent with Bray et al. (2004), who identified widespread public confusion regarding carbohydrates and their relationship with obesity and dietary health. Students' difficulty distinguishing between beneficial dietary carbohydrates and unhealthy sources of refined sugars may reflect broader societal messages that categorize carbohydrates as universally harmful. This finding highlights the importance of nutrition instruction that emphasizes scientific distinctions among simple carbohydrates, complex carbohydrates, dietary fiber, and glucose metabolism.

The results of this study are also consistent with research examining misconceptions related to fats and lipids. Auld et al. (1994) found that students frequently possessed inaccurate beliefs regarding dietary fats and cholesterol, often viewing all fats as harmful regardless of their physiological functions. Similarly, Morton et al. (2008) demonstrated that undergraduate students in physiology and biochemistry courses maintained misconceptions regarding biological molecules despite completing formal instruction. The persistence of misconceptions observed in the present study suggests that traditional lecture-based instruction may increase exposure to scientific terminology but may not sufficiently challenge students' preexisting conceptual frameworks.

The use of two-tier and three-tier diagnostic assessments with the modified Certainty Response Index (CRI) provided additional insight into the nature of students' misconceptions. The findings support Hasan et al. (1999), who demonstrated that confidence-based diagnostic assessments are effective in distinguishing misconceptions from simple lack of knowledge. Traditional assessments often identify incorrect responses but fail to determine whether students possess firmly held alternative conceptions or merely lack information. By incorporating students' confidence levels and reasoning explanations, this study was able to identify misconceptions that may have otherwise remained hidden. These findings align with Gurel et al. (2015), who emphasized that multi-tier diagnostic instruments provide a more accurate assessment of students' conceptual understanding than conventional multiple-choice tests.

The findings regarding nutrition probe-based learning support the broader literature on formative assessment and conceptual change. Students who participated in nutrition probes and exit tickets demonstrated changes in their understanding of macronutrient concepts, suggesting that engaging students in prediction, explanation, and reflection activities can promote conceptual development. These results are consistent with Keeley's (2015) argument that formative assessment probes are effective tools for revealing students' prior knowledge and facilitating instructional adjustments. Similarly, Chin and Teou (2009) found that formative assessment strategies requiring students to explain their reasoning promote deeper scientific understanding by encouraging students to evaluate and revise their explanations.

The effectiveness of nutrition probes observed in this study is also consistent with retrieval-based learning research. Karpicke (2012) demonstrated that active retrieval improves long-term learning because students strengthen knowledge structures when they actively recall and apply information. Rather than passively receiving nutrition information, students participating in nutrition probes were required to predict outcomes, explain their reasoning, and compare their ideas with scientific explanations. This process likely contributed to improved conceptual understanding by encouraging students to reconstruct their knowledge of carbohydrates, proteins, and lipids.

However, the persistence of some misconceptions after the intervention indicates that conceptual change is a gradual process rather than an immediate outcome of instruction. Previous conceptual change researchers have emphasized that students may retain alternative conceptions even after receiving scientifically accurate explanations because existing knowledge structures are often resistant to change (Posner et al., 1982; Strike & Posner, 1982). Therefore, although nutrition probes represent a valuable instructional strategy, sustained conceptual change may require multiple opportunities for students to confront misconceptions across different learning activities, assessments, and real-world applications.

The findings also have implications for teaching non-major biology courses. Because many students enrolled in introductory biology courses do not intend to pursue science careers, instructors may underestimate the importance of developing strong conceptual understanding. However, as future consumers, community members, and decision-makers, these students require sufficient nutrition literacy to evaluate health information and make informed dietary choices. The current study demonstrates that introductory biology courses provide an important opportunity to integrate scientific literacy and health education.Toward this end, the findings contribute to the literature by demonstrating that nutrition misconceptions are prevalent among college students and that nutrition probe-based formative assessment can serve as an effective strategy for identifying and addressing these misconceptions. The results reinforce previous empirical evidence supporting conceptual change approaches, diagnostic assessment tools, and active learning strategies in improving undergraduate science education.

CONCLUSION AND POLICY IMPLICATIONS

This study examined nutrition misconceptions among undergraduate students enrolled in a non-majors introductory biology course and evaluated the impact of nutrition probe-based learning on students' conceptual understanding of carbohydrates, proteins, and lipids. The findings demonstrated that students entered the course with several misconceptions regarding macronutrient classification, dietary sources, energy functions, and biological roles. These misconceptions were particularly evident in students' understanding of carbohydrates, including confusion regarding carbohydrate sources, complex carbohydrates, and the relationship between carbohydrates and energy metabolism. The use of two-tier and three-tier diagnostic assessments combined with the Certainty Response Index provided a comprehensive approach for identifying misconceptions by distinguishing between incorrect responses caused by misunderstanding and those caused by uncertainty or lack of knowledge. This approach demonstrated that misconceptions represent deeply established alternative explanations rather than simple informational gaps.

The findings further demonstrated that nutrition probe-based learning and formative assessment activities contributed to improvements in students' conceptual understanding. By requiring students to predict, explain, and reflect on nutrition concepts, the intervention encouraged active learning and supported conceptual change. However, the persistence of some misconceptions after instruction indicates that addressing nutrition misconceptions requires continuous reinforcement, multiple instructional opportunities, and integration of nutrition concepts throughout biology curricula. The study contributes to the growing literature on science education by demonstrating the importance of addressing misconceptions in introductory biology classrooms, particularly among non-science majors. Because these students represent future professionals, community members, and consumers, improving their nutrition literacy extends beyond classroom achievement and contributes to broader public health goals.

Policy Implications

The findings of this study have several important implications for higher education policy, curriculum development, and public health education. First, institutions of higher education should consider integrating nutrition literacy outcomes into general education science requirements. Many undergraduate students complete introductory biology courses as part of their general education curriculum; therefore, these courses provide an ideal setting for developing scientifically informed health behaviors. Universities should encourage curriculum frameworks that connect biological concepts with real-world health applications, including nutrition, chronic disease prevention, and evidence-based dietary decision-making.

Second, biology departments should consider adopting diagnostic assessment strategies, such as two-tier and three-tier misconception assessments, as part of routine instructional practice. Traditional examinations may identify whether students answer questions correctly but provide limited information about why students misunderstand concepts. Incorporating misconception assessments can assist instructors in identifying problematic areas early and designing targeted instructional interventions. Third, faculty development initiatives should promote the use of active learning and formative assessment strategies. The effectiveness of nutrition probes observed in this study suggests that instructors should move beyond lecture-centered approaches and incorporate activities that require students to explain their reasoning, evaluate evidence, and revise misconceptions. Institutions should provide professional development opportunities that prepare faculty to implement conceptual change strategies, retrieval-based learning activities, and formative assessment techniques.

Fourth, policymakers and higher education leaders should recognize the relationship between science education and public health outcomes. Nutrition misinformation contributes to poor dietary decisions and increased risk of chronic diseases. Improving nutrition literacy among college students may serve as a preventive health strategy by equipping individuals with the knowledge necessary to evaluate nutrition claims and make healthier lifestyle decisions. Fifth, HBCUs and other minority-serving institutions may benefit from developing culturally responsive nutrition education initiatives. Because health disparities disproportionately affect underserved communities, improving nutrition literacy within diverse student populations may contribute to broader efforts to reduce preventable health inequities. Nutrition education programs should incorporate culturally relevant examples, community food practices, and practical applications that reflect students' lived experiences.

Finally, future institutional policies should support longitudinal evaluation of nutrition education interventions. While this study demonstrated short-term changes in students' conceptual understanding, additional research is needed to determine whether nutrition probe-based learning produces sustained improvements in nutrition knowledge, dietary behaviors, and health outcomes. Future studies should examine multiple institutions, diverse student populations, and long-term effects of conceptual change interventions. In conclusion, addressing nutrition misconceptions among college students requires collaboration among educators, administrators, and public health professionals. By integrating evidence-based instructional strategies, diagnostic assessment tools, and nutrition literacy initiatives into undergraduate education, institutions can better prepare students to make informed health decisions and contribute to healthier communities.

REFERENCES

Abimbola, I. O. (1988). The problem of terminology in the study of student conceptions in science. *Science Education, 72*(2), 175–184.

Anderson, T., & Grayson, D. (1994). Improving students' understanding of carbohydrate metabolism in first-year biochemistry at tertiary level. *Research in Science Education, 24*(1), 1–10.

Auld, G. W., Achterberg, C. L., Getty, V. M., & Durrwachter, J. G. (1994). Misconceptions about fats and cholesterol: Implications for dietary guidelines. *Ecology of Food and Nutrition, 33*(1–2), 15–25.

Aydın, Ö. (2007). *Assessing tenth grade students' difficulties about kinematics graphs by a three-tier test* (Unpublished master's thesis). Middle East Technical University.

Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. *ASEE National Conference Proceedings*, Atlanta, GA, 30(9), 1–18.

Bledsoe, K. E. (2013). Starch is very fatty: Understanding the logic in undergraduate student conceptions about biological molecules. *Electronic Journal of Science Education, 17*(2), 1–35.

Bray, G. A., Nielsen, S. J., & Popkin, B. M. (2004). Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *The American Journal of Clinical Nutrition, 79*(4), 537–543.

Bruning, R., Schraw, G. J., & Ronning, R. R. (1999). *Cognitive psychology and instruction*. Upper Saddle River, NJ: Prentice Hall.

Chin, C., & Teou, L. Y. (2009). Using concept cartoons in formative assessment: Scaffolding students' argumentation. *International Journal of Science Education, 31*(10), 1307–1332.

Clement, J. (2008). The role of explanatory models in teaching for conceptual change. In S. Vosniadou (Ed.), *International handbook of research on conceptual change*. Mahwah, NJ: Erlbaum.

Crombie, A. P., Ilich, J. Z., Dutton, G. R., Panton, L. B., & Abood, D. A. (2009). The freshman weight phenomenon revisited. *Nutrition Reviews, 67*(2), 18–94.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297–334.

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970–977.

Deliens, T., Clarys, P., Van Hecke, L., De Bourdeaudhuij, I., & Deforche, B. (2013). Changes in weight and body composition during the first semester at university: A prospective explanatory study. *Appetite, 65*, 111–116.

Dickson-Spillmann, M., & Siegrist, M. (2011). Consumers' knowledge of healthy diets and its correlation with dietary behaviour. *Journal of Human Nutrition and Dietetics, 24*(1), 54–60.

Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*(7), 5–12.

Driver, R., & Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education, 13*(1), 105–122.

Dreyfus, A., Jungwirth, E., & Eliovitch, R. (1990). Applying the "cognitive conflict" strategy for conceptual change—Some implications, difficulties, and problems. *Science Education, 74*(5), 555–569.

Eryilmaz, A. (2010). Development and application of three-tier heat and temperature test: Sample of bachelor and graduate students. *Eurasian Journal of Educational Research, 40*, 53–76.

Fedewa, M. V., Das, B. M., Evans, E. M., & Dishman, R. K. (2014). Change in weight and adiposity in college students: A systematic review and meta-analysis. *American Journal of Preventive Medicine, 47*(5), 641–652.

Fisher, K. M. (1985). A misconception in biology: Amino acids and translation. *Journal of Research in Science Teaching, 22*(1), 53–62.

Fraenkel, J., & Wallen, N. (2008). *How to design and evaluate research in education*. New York, NY: McGraw Hill.

Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(5), 989–1008.

Hasan, S., Bagayoko, D., & Kelley, E. L. (1999). Misconceptions and the certainty of response index (CRI). *Physics Education, 34*(5), 294–299.

Hawthorne, K. M., Moreland, K., Griffin, I. J., & Abrams, S. A. (2006). An educational program enhances food label understanding of young adolescents. *Journal of the Academy of Nutrition and Dietetics, 106*(6), 913–916.

Herreid, C. (2006). Clicker cases: Introducing case study teaching into large classrooms. *Journal of College Science Teaching, 36*(2), 43–47.

Hewson, P. W. (1981). A conceptual change approach to learning science. *European Journal of Science Education, 3*(4), 383–396.

Hewson, M. G., & Hewson, P. W. (1983). Effect of instruction using students' prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching, 20*(8), 731–743.

Inagaki, K., & Hatano, G. (2008). Conceptual change in naïve biology. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 240–262). New York, NY: Routledge.

Karpicke, J. D. (2012). Retrieval-based learning: Active retrieval promotes meaningful learning. *Current Directions in Psychological Science, 21*(3), 157–163.

Keeley, P. (2015). *Science formative assessment: 75 practical strategies for linking assessment, instruction and learning*. Thousand Oaks, CA: Corwin Press.

Kelley, R. M., Barrera, J. H., & Mohamed, S. C. (2009). An analysis of undergraduate general chemistry students' misconceptions of the submicroscopic level of precipitation reactions. *Journal of Chemical Education, 87*(1), 113–118.

Karpicke, J. D. (2012). Retrieval-based learning: Active retrieval promotes meaningful learning. *Current Directions in Psychological Science, 21*(3), 157–163.

Lang, J. M. (2016). *Small teaching: Everyday lessons from the science of learning*. San Francisco, CA: Jossey-Bass.

Morton, J. P., Doran, D. A., & MacLaren, D. P. (2008). Common student misconceptions in exercise physiology and biochemistry. *Advances in Physiology Education, 32*(2), 142–146.

National Research Council. (1997). *Science teaching reconsidered: A handbook*. Washington, DC: National Academy Press.

Novak, J. D., & Gowin, D. R. (1984). *Learning how to learn*. Cambridge, UK: Cambridge University Press.

Peşman, H., & Eryılmaz, A. (2010). Development of a three-tier test to assess misconceptions about simple electric circuits. *The Journal of Educational Research, 103*(3), 208–222.

Popham, W. J. (2008). All about assessment: A misunderstood grail. *Educational Leadership, 66*(1), 82–83.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211–227.

Sharf, M., Sela, R., Zentner, G., Shoob, H., Shai, I., & Stein-Zamir, C. (2012). Figuring out food labels: Young adults' understanding of nutritional information presented on food labels is inadequate. *Appetite, 58*(2), 531–534.

Snow, J., & Mann, M. (2013). *Qualtrics survey software*. Handbook for Research Professionals. Provo, UT: Qualtrics Labs, Inc.

Stojanovska, M., Šoptrajanov, B., & Petruševski, V. M. (2017). Misconceptions in chemistry teaching regarding oxidation reactions of monosaccharides. *Contributions, Section of Natural, Mathematical and Biotechnical Sciences, 34*(1–2), 1–12.

Strike, K. A., & Posner, G. J. (1982). Conceptual change and science teaching. *European Journal of Science Education, 4*(3), 231–240.

Treagust, D. F. (1986). Evaluating students' misconceptions by means of diagnostic multiple choice items. *Research in Science Education, 16*(1), 199–207.

Vosniadou, S., Vamvakoussi, X., & Skopeliti, I. (2008). The framework theory approach to the problem of conceptual change. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 3–34). Mahwah, NJ: Erlbaum.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 177–210). New York, NY: Macmillan.

Yong, C. L. (2017). Utilizing concept cartoons to diagnose and remediate misconceptions related to photosynthesis among primary school students. In *Overcoming students' misconceptions in science* (pp. 9–27). Singapore: Springer.

Zoellner, J., Connell, C., Bounds, W., Crook, L., & Yadrick, K. (2009). Nutrition literacy status and preferred nutrition communication channels among adults in the lower Mississippi Delta. *Preventing Chronic Disease, 6*(4), A128.