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Assessing the impact of integrated nutrition education within life sciences on eating behavior among school- aged Moroccan adolescents: A study of construct validity for a measurement instrument

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Abstract: The study aimed to create and validate a test to assess the impact of integrated nutrition education in life science courses on the behavior of Moroccan school-aged adolescents, based on situational judgment test theory. The development process involved reviewing the middle school life science curriculum, conducting semi-structured interviews with educational inspectors and nutritionists, establishing a concordance panel, and carrying out a preliminary study with 378 participants from the second and third years of middle school before the main study. The test demonstrated strong internal consistency ($\alpha = 0.89$, $p < 0.05$), suggesting its reliability and validity. Data analysis showed that participant scores followed a normal distribution ($p = 0.2$) and exhibited significant variation based on school grade ($p = 0.001$). Within the test dimensions, "diet control" and "food selection" showed significant correlations (Pearson coefficients of 0.67 and 0.66, respectively). In contrast, "food preferences" and "health, diet, and well-being" displayed weaker correlations (0.46 and 0.43, respectively). The review provides valuable insights that educators and policymakers can use to assess and improve existing nutrition education initiatives. The test contributes to enhancing nutrition education, promoting healthy eating, and preventing obesity and diabetes by identifying the strengths and weaknesses of the educational approach, leading to more informed policies.

Keywords: *Adolescents, Eating behavior, Integration, Life sciences, Morocco, Nutrition education.*

1. Introduction

Morocco, as a country in a phase of economic, social and nutritional transition, faces growing food-related health challenges [1]. Adolescents, a particularly vulnerable demographic, are deeply impacted by the convergence of recent trends [2]. The globalization of food consumption patterns, characterized by the widespread availability of processed and fast foods, has presented new challenges to healthy eating. Rapid urbanization, with its associated changes in lifestyle and dietary habits, has further complicated the issue [3]. Additionally, shifts in family structure, such as the increasing number of single-parent households and dual-income families, can affect meal planning and preparation, potentially leading to less healthful dietary choices. This transition from traditional diets to more Westernized eating patterns could have had a significant impact on the eating behaviors of Moroccan teenagers [4]. In this context, it is found that the prevalence of obesity, diabetes, and other diet-related health problems has increased in many countries, including Morocco [5]. These transitions may affect the dietary behaviors of Moroccan adolescents, thereby emphasizing the need for educational interventions that positively support these nutritional changes. Indeed, one of the most appropriate disciplines for

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integrating nutritional education into the curriculum is life sciences. In this context, the Moroccan educational program aims to incorporate nutritional education into school curricula at various levels, including the final stage of secondary education.

Indeed, nutrition education plays a crucial role in promoting healthy eating habits and preventing diet-related diseases. The integration of nutrition education into the life sciences curriculum offers a unique opportunity to enhance students' understanding of the relationship between diet, health, and the environment. By combining scientific knowledge with practical applications, students can develop the skills and knowledge necessary to make informed food choices. Thus, integrated nutrition education in the life sciences allows students to understand how food interacts with the human body, influencing growth, development, and overall health [6]. This approach provides students with a practical perspective, enhancing knowledge retention and enabling the concrete application of what they have learned, particularly regarding the impact of this integration on their eating behaviors.

On the other hand, it is important to highlight that the current approach to nutritional education promotes the exchange of information between educators and the community. It empowers individuals to make informed choices based on both scientific knowledge and local expertise. Furthermore, this approach leads to improved behaviors and contributes to achieving sustainable outcomes and meaningful changes [7].

Numerous scientific studies have demonstrated that integrating nutrition education into science teaching requires a systematic approach.

This approach must include an interdisciplinary curriculum, teacher training, community involvement, and the use of diverse resources. Such a strategy helps create an educational environment that promotes students' health and well-being while enhancing their scientific knowledge and decision-making skills [8].

It should be noted that, importantly, modifying human behavior generally follows a gradual process, which must be considered in any communication intervention aimed at changing this behavior [9].

In this context, regardless of the methods and approaches adopted to integrate nutrition education into the life sciences learning process, assessing the impact of this integration still represents a challenge for all educational players. It is therefore necessary to have a valid and reliable tool for accurately assessing the impact of this integration on the dietary behavior of Moroccan adolescents to detect the strengths and weaknesses of this integration, which would enable teachers to better adapt their learning approaches and methods and decision-makers to carry out the necessary pedagogical reforms. This study aims to develop and validate a situational judgment test (SJT) to Assessing the Impact of Integrated Nutrition Education within Life Sciences on Eating Behavior Among School- aged Moroccan Adolescents.

This study employed a comprehensive methodological approach to develop and validate a measurement instrument aimed at assessing the impact of integrating nutrition education (NE) with life sciences (LS) learning on the eating behaviors of Moroccan school-going adolescents. Our objective was to gain a deeper understanding of the relationship between knowledge and healthy eating practices within this population, thereby contributing to the promotion of a balanced and rational lifestyle. By developing and validating a reliable measurement tool, this study aims to provide a solid foundation for in-depth analysis and practical recommendations for educators and policymakers seeking to effectively integrate nutrition education into the school curriculum. Ultimately, this research seeks to contribute to the promotion of healthy eating behaviors from an early age, prevent nutrition-related diseases, and enhance the general well-being of Moroccan adolescents.

This research revolves around the following main question: What tools or methods can be used to evaluate the impact of integrated nutrition education within the life sciences curriculum on the eating behaviors of school-going adolescents in Morocco? From this main question, several secondary questions arise, allowing for an exploration of different aspects of evaluation, including:

- What criteria should be considered when selecting an evaluation tool suitable for adolescents?

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- Which qualitative and quantitative methods are most effective in measuring changes in eating behavior?
- What is the most relevant approach for developing a measurement tool to assess the impact of integrated nutrition education within the life sciences curriculum on the eating behaviors of school-going adolescents in Morocco?

This main question is essential, as it focuses on the evaluation instruments necessary to measure the effects of nutrition education on eating behaviors. Understanding how to assess this impact is crucial for developing effective and tailored interventions, thereby identifying the strengths and weaknesses of this integration within the school curriculum. By exploring this issue, we aim to provide concrete recommendations to improve educational practices regarding nutrition in Morocco.

2. Literature Review

Behavior is defined as a set of observable verbal and gestural reactions of an individual in his or her environment and in given circumstances. It refers to the way in which individuals act or react in different situations. It encompasses a wide range of observable responses, from physical actions to emotional and cognitive responses [10].

Behavior is often influenced by several factors, such as personality, past experiences, social context, motivations and internal impulses. It can be studied in various fields, such as psychology, biology, sociology and ethology, to better understand human beings and other animal species [11]. This implies that there is great complexity in studying human behavior, and consequently, from a methodological point of view, studying behavior requires a holistic approach [12].

Indeed, the theory of reasoned action (TRA) [13] and the theory of planned behavior (TPB) [14] were intended explicitly to predict and explain social behavior via a small number of psychological constructs, such as attitudes, subjective norms, perceived behavioral control and behavioral intentions.

This parsimony makes them easily applicable to a wide spectrum of behaviors, which explains why TRA and TPB have remained the dominant theories in the study of behavioral decision-making and in the study of the relationship between attitudes and the social behavior of individuals for over twenty years [15]. There is therefore an important relationship between attitude and the triggering of behavior, so that attitude must comprise both a set of cognitions (beliefs or opinions) and a set of affective responses to this object (emotions or feelings). If there is a certain consistency between these components, we increase the chances of seeing a set of behaviors or behavioral tendencies emerge [16].

In this context, the deterministic perspective recognizes three main categories of factors likely to influence individual attitudes and behaviors: personal characteristics (P), object characteristics (O), and environmental or situational elements (S). In the case of food, this approach has enabled us to identify the main factors influencing consumption choices and to develop classifications. This section first explains the philosophy behind POS models, followed by their application in the field of food consumption [17].

The main approach adopted is behaviorist: it asserts that an individual's behavior is a "black box" whose functioning can be only partially deduced [18]. It is closely linked to the context and circumstances in which a person lives.

From this point of view, assessing behavior involves evaluating the abilities and reactions of individuals in different situations. It is necessary to differentiate between the assessment of knowledge, abilities, skills and competencies (KASC) and the assessment of behavior.

The assessment of KASC can often be performed through questions and items that test knowledge and the ability to apply this knowledge in given situations, whereas the assessment of behavior requires a different approach. To assess behavior, it is important to create realistic situations that place individuals in scenarios where their actual behavior can be observed and evaluated. This often involves creating simulations, role-plays or case studies that reflect the challenges and contexts that individuals face in their lifestyle [19].

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In this context, to assess the eating behavior of Moroccan adolescents, an approach that considers all these circumstances is needed.We find that the design of the Situational Judgment Test (SJT) is suitable for developing a test to assess the impact of integrated nutrition education (NE) into life science (LS) learning on the behavior of Moroccan adolescents.Indeed, the SJT is a precise approach that aims to assess the behavior of individuals in specific situations. The theoretical principles that support the argument that SJT can serve as a predictor of success at work are based on two main concepts. The first principle is based on behavioral consistency, asserting that past behavior is the best indicator of future behavior. The second concept is the implicit trait policy (ITP) [20].

Using this approach, evaluators present participants with a series of realistic situations and ask them how they would react or act in each given situation. The participants' responses are then used to assess their ability to cope with various situations, their decision-making, problem-solving, creative thinking, psychosocial skills and so on.

We believe that this approach can offer valuable insights into people's actual eating behavior in real-life situations, which can be difficult to assess through questions or knowledge tests alone.

3. Material and Method

3.1. Research Design

This study seeks to develop and validate a test as a measurement instrument to evaluate the impact of nutrition education integrated into life sciences curricula on the dietary behaviors of Moroccan adolescents. The research employs a situational judgment test (SJT) approach, which assesses students' decision-making and reactions to various scenarios related to nutrition and health.

3.1.1.Study Population

The study population consists of adolescents enrolled in the 2nd and 3rd years of middle school. The sample was stratified based on the type of environment (urban versus rural) and the type of school (public versus private). Two urban schools were selected, one public and the other private, while one rural public school was chosen. This stratification allows for a comparative analysis of differences in nutritional behavior across these variables.

3.1.2. Data Collection Instrument

The primary data collection tool is a situational judgment test (SJT) designed to measure students' knowledge and attitudes by presenting them with realistic, nutrition-related scenarios. Students are required to choose the most appropriate responses in each situation. The test was developed in collaboration with experts in nutrition education and underwent a pilot study to ensure content validity and clarity.

3.1.3. Instrument Validity and Reliability

The validity of the instrument was rigorously established through expert review by specialists in nutrition and education. A pilot test was conducted with a sample group to ensure the clarity and applicability of the test items. The reliability of the instrument was confirmed through internal consistency measures, with Cronbach's alpha.

3.2. Data Collection Procedure

Data collection was carried out over a three-month period, from January to March 2024, in the three selected institutions. Students were administered the situational judgment test under controlled classroom conditions, ensuring a standardized testing environment. Prior to participation, informed consent was obtained from the parents, adhering to ethical guidelines for research involving minors.

3.2.1.Data Analysis

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The collected data were analyzed using SPSS version 25. Descriptive statistics were employed to summarize the demographic and behavioral characteristics of the participants. Inferential statistical analyses were performed to examine the impact of the nutrition education program, with particular focus on differences across school types and environments (urban vs. rural). The analyses aimed to identify statistically significant variations in dietary behavior linked to the educational intervention.

3.2.2. Data Source and Ethical Considerations

The data for this study were sourced directly from students enrolled in the three selected middle schools. All data collection and analysis procedures adhered to stringent ethical standards, particularly with regard to confidentiality and the protection of minors. Participation was entirely voluntary, and the data were anonymized to safeguard participant privacy.

3.3.Test Frame of Reference

First, we tried to identify the cognitive domains and nutritional education (NE) skills targeted by life science (LS) pedagogical orientations at the college cycle grade to cover the different axes that could influence and guide the eating behavior of adolescents.

Following an analysis of the life sciences curriculum for the secondary school cycle and the results of semistructured interviews with three educational inspectors specializing in life and earth sciences (LES) and with two nutrition experts, three principals were selected to develop a frame of reference for assessing the impact of integrating NE into LS learning on the behavior of Moroccan adolescents.

On the other hand, to cover the cognitive domains, we subdivide each domain into four subdomains.The development of the reference test is based on three principles:

3.3.1.Principle 1: Targeted Cognitive Domains

There are four main cognitive domains targeted by nutrition education:

3.3.1.1. Area 1: Food Moderation

Food moderation consists of consuming a variety of foods while respecting health standards and avoiding excess. It allows us to meet our body's needs and is the set of actions that enable us to regulate our eating behaviors to maintain a balance between health, nutrition and well-being [21].

This domain is made up of four subdomains as follows (Figure 1).

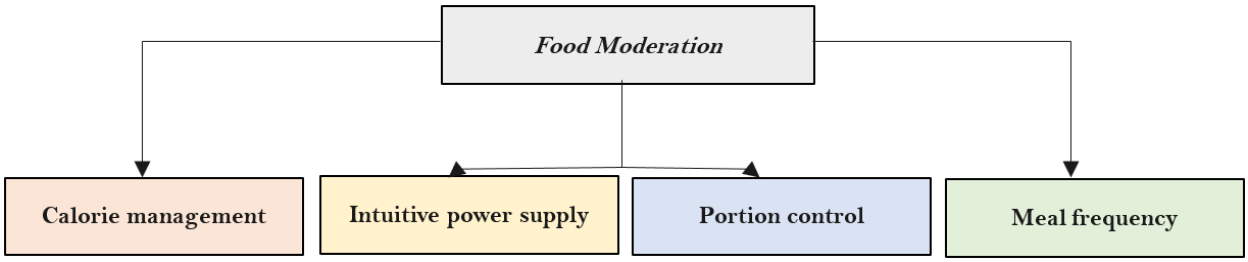

Figure 1.
Subdomains of dietary moderation.

3.3.1.2.Area 2: Food choices

Food choice refers to the decisions an individual makes about the foods he or she eats. These choices are influenced by various factors, such as personal preferences; nutritional needs; cultural, religious or ethical beliefs; physiological processes; health; and environmental and economic considerations. As a result, food choices can vary considerably from one person to another and can change over time depending on various factors and situations. There are several theoretical approaches and models that attempt to explain the interactions and feedbacks between the different factors that govern food choice in individuals [17]. This domain is made up of 4 Subdomains (Figure 2).

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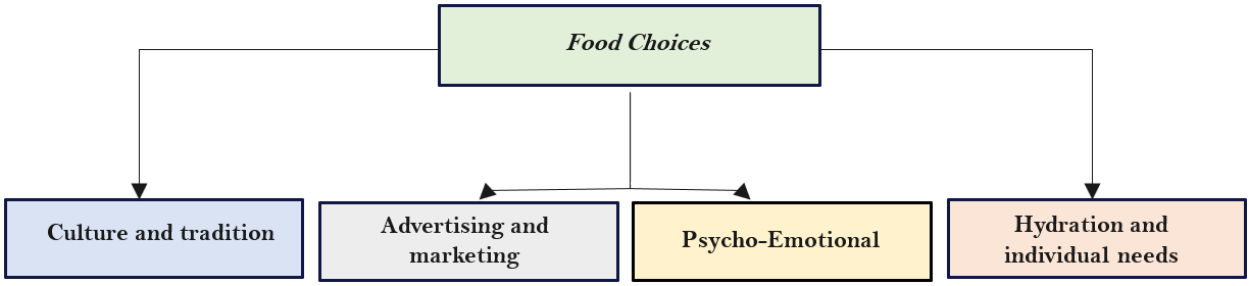

Figure 2.
Subdomains of food choice.

3.3.1.3.Area 3: Food preference

Food preference is a complex area that is subject to diverse influences, such as culture, religion, individual experience and biological aspects. Understanding these preferences is crucial for a number of reasons, not least to design appropriate nutritional programs and promote understanding across different cultures.

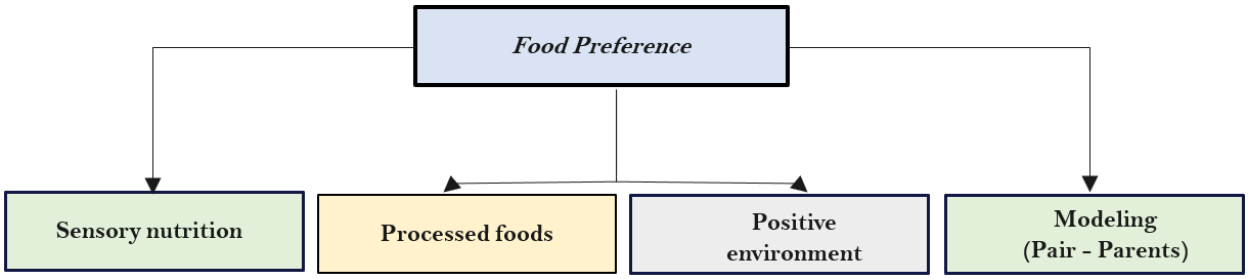

Figure 3.
Subdomains of food preference.

It is defined as the degree of liking or disliking for a food, involving a choice between several options. In fact, food preference is influenced by several factors, such as early experiences of unfamiliar flavors and textures, parental acceptance of foods, advertising and family eating behaviors [22]. This domain is made up of four subdomains as follows (Figure 3).

3.3.1.4. .Area 4: Well-Being, Food and Health

The influence of diet on well-being, health and mental state is significant. A balanced diet rich in fruit, vegetables, whole grains and nutrients plays a crucial role in maintaining physical, mental and emotional health. Indeed, a balanced diet combined with quality sleep forms the essential pillar of well-being. These two elements complement each other to maintain optimal health and lasting energy. Notably, combining a balanced diet with regular exercise strengthens not only the body but also the mind. Indeed, these findings show that food choices have a direct effect on human health. Moreover, avoiding excessive snacking between meals maintains nutritional balance and prevents undesirable fluctuations in blood sugar grade s. In a world dominated by technology, striking a balance between our diet and our use of digital devices is crucial [23]. Limiting technological distractions during meals promotes mindful eating and better digestion (Figure 4).

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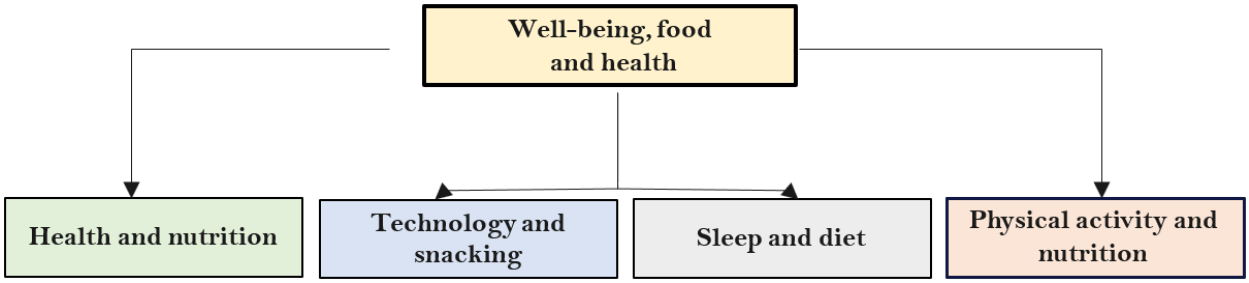

Figure 4.
Subdomains of well-being, food and health.

3.3.2. Principle 2 Types of skills targeted for each domain

3.3.2.1. Type 1: Decision-making

Making a decision involves choosing between different options, either to take action or to abstain. This choice is intrinsically linked to action and is guided by various factors, such as context, the decision maker's experience, the importance of the situation and the constraints at play. These constraints encourage the decision maker to adjust his or her behavior according to the complexity and evolution of the situation [24]. To further explore the relationship between food choice and decision-making in the context of eating behavior, we believe that it is essential to consider a variety of psychological, neurobiological and sociocultural factors.

3.3.2.2. Type 2: Critical Thinking

Critical thinking is a form of intellectual exercise in which a statement, source or belief is examined with integrity to assess its accuracy, validity or usefulness. It is characterized by a logical approach based on questioning and challenging presuppositions and preconceived ideas. This intellectual method aims to cultivate the capacity for intellectual autonomy and to make decisions free of cognitive bias [25].

Critical thinking generally involves the ability to think rationally and understand the logical connection between ideas. In the context of eating behavior, this could refer to how individuals make decisions about food, respond to dietary advice, or even manage emotional eating.

3.3.2.3.Type 3: Psychosocial

The psychosocial concept encompasses the connection between the mental and social components of a human being, shaping his or her thoughts, emotions and actions within society. These elements include attitudes, feelings, support networks, family and community ties, and cultural impacts [26]. Psychosocial skills, which include abilities such as emotional regulation, stress management and interpersonal communication, can significantly influence an individual's eating behaviors and behaviors.

3.3.2.4.Type 4: Integrative Thinking

Integrative thinking is a concept of decision-making and problem-solving that involves synthesizing diverse and often conflicting information and perspectives to generate innovative solutions and ideas [27]. This approach is particularly valuable in complex scenarios where no clear solution is apparent and traditional linear thinking fails to deliver satisfactory results.

In the context of academic research, especially in fields such as the study of eating behavior, integrative thinking could play a crucial role. It enables researchers to combine insights from different disciplines, such as psychology, neuroscience and sociology, to better understand and address complex issues related to eating behavior.

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3.3.3.Principle 3: Degree of Importance and Specification Table

The degree of importance of the cognitive domains and types of skills targeted is determined through a focus group composed of five (5) experts in education, three (3) experts in nutrition and two (2) experts in psychology.

We reached a consensus on the following weightings:

3.3.3.1.Degree of Importance of Targeted Cognitive Domains (Figure 5).

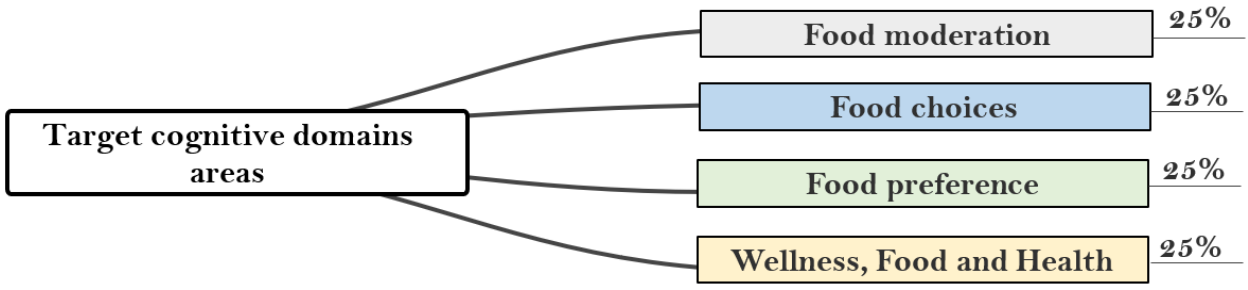

Figure 5.
Degree of importance of targeted cognitive domains.

3.3.3.2.Target Skill Areas (Figure 6).

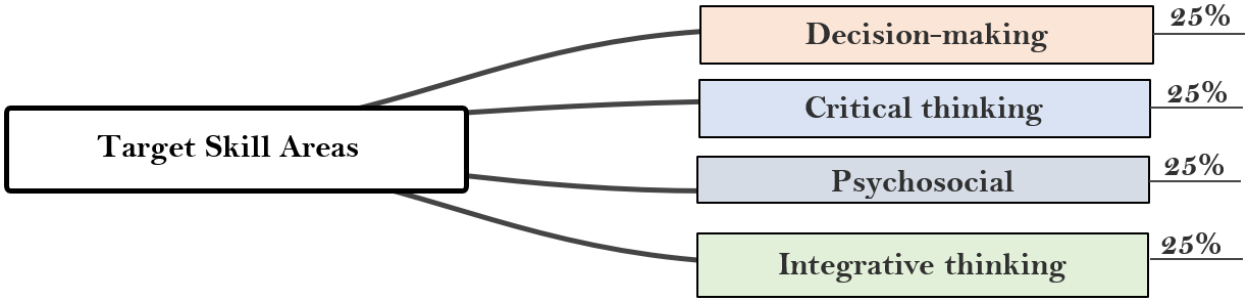

Figure 6.
The importance of targeted competencies.

3.3.3.3. Specification Tables

To develop a situational judgment test based on preestablished cognitive domains and skills assessing the impact of integrated nutrition education into life science learning on adolescents' eating behavior, it is essential to use a specification table. This tool is fundamental in the design of educational tests, as it enables the situations presented in the test to be aligned with the preestablished cognitive skills and objectives targeted. The specification table has two dimensions: on the one hand, the cognitive domains and skills to be assessed are listed, and on the other hand, the situations are presented.

Each box in the table indicates the number of situations designed to assess a specific skill related to a given cognitive domain.

3.3.3.3.1. Importance of Skills According to Targeted Cognitive Domains

The importance attached to the skills in each area is determined by the objectives of nutrition education and the nature of the situations that correspond to them (Table 1).

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Table 1.
The importance of skills and cognitive domains

Targeted cognitive domains	Targeted cognitive domains	Subdomain importance rate	Target skills	Importance of skills	Number of situations	Subdomain importance rate/domain
Food moderation	Calorie management	1%	Decision-making	6.25%	1	25%
	Intuitive power supply	1%	Critical thinking	6.25%	1	
	portion control	1%	Psychosocial	6.25%	1	
	Meal frequency	1%	Integrative thinking	6.25%	1	
Food choice	Culture and tradition	1%	Decision-making	6.25%	1	25%
	Advertising and marketing	1%	Critical thinking	6.25%	1	
	Psycho-Emotional	1%	Psychosocial	6.25%	1	
	Hydration and individual needs	1%	Integrative thinking	6.25%	1	
Food preference	Sensory nutrition	1%	Decision-making	6.25%	1	25%
	Processed foods	1%	Critical thinking	6.25%	1	
	Positive environment	1%	Psychosocial	6.25%	1	
	Modeling (Pair and Parents)	1%	Integrative thinking	6.25%	1	
Wellness, food and health	Health & nutrition	1%	Decision-making	6.25%	1	25%
	Technology and snacking	1%	Critical thinking	6.25%	1	
	Sleep and diet	1%	Psychosocial	6.25%	1	
	Physical activity and nutrition	1%	Integrative thinking	6.25%	1	
Total				100%	16	100%

3.3.3.3.2. Importance of Cognitive Domains and Targeted Skills

The total rate is determined via the following procedure: the rate of importance of the skills is multiplied by the rate of importance of the subdomains of the targeted cognitive domains (Table 2).

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Table 2.
Specification table.

Cognitive domains	Subareas	Importance rate (Cognitive domains × skills)				Total
		Decision-making	Critical thinking	Psychosocial	Integrative thinking	
Food moderation	Calorie management	6.25% ×1%				6.25%
	Intuitive power supply		6.25% ×1%			6.25%
	portion control			6.25% ×1%		6.25%
	Meal frequency				6.25% ×1%	6.25%
Food choice	Culture and tradition	6.25% ×1%				6.25%
	Advertising and marketing		6,25% ×1%			6.25%
	Psycho-Emotional			6.25% ×1%		6.25%
	Hydration and individual needs				6.25% ×1%	6.25%
Food preference	Sensory nutrition	6.25% ×1%				6.25%
	Processed foods		6.25% ×1%			6.25%
	Positive environment			6.25% ×1%		6.25%
	Modeling (Pair and Parents)				6.25% ×1%	6.25%
Well-Being _ food and health	Health and nutrition	6.25% ×1%				6.25%
	Technology and snacking		6.25% ×1%			6.25%
	Sleep and diet			6.25% ×1%		6.25%
	Physical activity and nutrition				6.25% ×1%	6.25%
Total		25%	25%	25%	25%	100%

3.4.Test Development

The test is based on the Situational Judgment Test (SJT), in which hypothetical and realistic scenarios are presented to participants. They are asked to choose the most appropriate response from a range of options, thus assessing their ability to apply their knowledge and skills in real-life situations.

3.4.1.Step 1: Defining Test Objectives

The main objective of this study was to develop a valid and reliable measurement instrument to assess the impact of integrated nutrition education into life science learning on adolescent behavior. The instrument includes scenarios requiring the occurrence of critical incidents to observe participants' reactions and choices.

3.4.2.Step 2: Test Design

The test consists of 16 situations designed to cover the four cognitive domains and the four target competencies specified in the reference test. These situations are concrete examples of nutritional choices and behaviors. Each situation is designed to assess the application of knowledge and skills in a specific cognitive domain and to target competency.

Each situation is accompanied by four response options. These options are evaluated according to a five-point Likert scale, which measures the participant's degree of agreement or appropriateness with the proposed response [28]. As a result, the evaluation situation consists of a primer with four (4) options and a five-point measurement scale (Table 3).

The Correct answers were determined by a concordance panel of 48 experts in nutrition, education, and psychology. Responses were evaluated based on their alignment with health-promoting behaviors and critical thinking skills.

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Table 3.
The structure of the eating behavior assessment situation.

Initiating the situation: the context and the critical incident					
The proposed reactions	**Evaluation scale**				
	Strongly agree (A)	**I agree (B)**	**Neutral (C)**	**Disagree (D)**	**Strongly disagree (E)**
Option 1 (R_1)	⬭	⬭	⬭	⬭	⬭
Option 2(R_2)	⬭	⬭	⬭	⬭	⬭
Option 3 (R_3)	⬭	⬭	⬭	⬭	⬭
Option 4 (R_4)	⬭	⬭	⬭	⬭	⬭

This is an example of a situation that aims to assess dietary moderation as a target cognitive domain (Table 4).

Table 4.
Example of an eating behavior assessment situation.

Scenario: You observe a classmate, Fatima, who frequently skips breakfast and complains of fatigue in class. In conversation with her, you discover that she often has a lack of appetite in the morning. Fatima also mentions that she has begun to rely on cheap, synthetic food products between meals, as they are readily available in her neighborhood. What action do you think Fatima should take?

The proposed reactions		**Evaluation scale**				
		Strongly Agree(A)	**I agree (B)**	**Neutral (C)**	**Disagree (D)**	**Strongly disagree(E)**
R_1	Continue to skip breakfast and rely on synthetic food products due to ease of access and low cost.	⬭	⬭	⬭	× ⬭	⬭
R_2	Ignore symptoms and hope they go away on their own.	⬭	⬭	⬭	⬭	× ⬭
R_3	Drink more coffee to stay awake in class, due to the lack of affordable nutritional options available.	⬭	⬭	⬭	⬭	× ⬭
R_4	Encourage Fatima to try eating her first bowl of food, even if she does not feel hungry.	× ⬭	⬭	⬭	⬭	⬭

Note: Correct answers are determined by the results of the concordance panel and are marked in the table above with a cross (×)

3.4.3.Step 3: Test Content Validation

To examine its relevance, clarity and validity, a panel of experts comprising five (5) educational inspectors, three (3) nutritionists and two (2) psychology experts evaluated the questionnaire. Adjustments were made in response to the experts' observations to ensure that the test accurately assessed its original purpose.

Next, the questionnaire's ability to assess the targeted cognitive and psychosocial skills was verified to ensure its credibility. The analysis also included an examination of correlations between testscores and other relevant measures, as well as the ability of test scores to predict future behaviors in contexts similar to those assessed. Finally, the internal consistency of the questionnaire's questions and scenarios was assessed to ensure reliable measurement of the target skills**.**

3.4.4. Step 4: Creating the Correction Grid and Swimming Scale

To ensure the validity and reliability of the scoring grid, a concordance panel of 48 experts in pedagogy, nutrition and psychology was set up. These experts provide diverse perspectives and expertise to ensure a balanced and relevant assessment of the participants' answers.

The grading scale consists of 5 points, allowing a gradual evaluation of participants' answers according to their relevance, accuracy and depth of analysis. The specific criteria for each scoring grade will be clearly defined to ensure a uniform and objective assessment.

3.4.5. Step 5: Calculating Participants' Scores

We are currently calculating participants' scores on a test consisting of 16 situations, each comprising 4 items. Each item is rated on a 5 point scale to assess the impact of integrating education into life science learning on adolescent behavior. The test is based on the TJS approach.

The scoring formula used in some assessment systems, notably the rating scales used in psychometric tests, calculates the points awarded to a response according to its position on the measurement scale.

In the present work, a rating scale of 1 to 5 was adopted to assess candidates' responses to each situation, where 1 represents the least appropriate response and 5 represents the most appropriate response. The formula could be adapted to assign points to each response according to its position on this scale.

We normalized the distance on a scale of 0 to 1 by dividing it by the maximum distance.

We then multiplied this normalized value by 5 to obtain a point scale from 0 to 5.We subtract this value from 5 to invert the scoring so that the score will be higher when the distance is shorter.Finally, we used the min function to ensure that the minimum score was 0.In our case, the maximum distance is 4, the minimum score is always 0 points, and the maximum score is 5 points. To calculate the score for each item, we use the following formula:

Points (item) $=(max\ (0.min\ (5.5-(Distance\ /max\ Distance)\times 5))$

- Distance: the distance between the correct answer and the participant's answer.
- Distance max :the maximum possible distance value (in this case, 4).

To calculate the score of points for each situation so that the maximum score is 5 points, we divide the following formula by 5:

Points (Situation)= $\sum_{IT=1}^{4}((max\ (0,min\ (5.5-(Distance\ /max\ Distance)\times 5))/4)$

The overall score of the test is calculated according to the following formula:

Points (test) = $\sum_{S=1}^{16}((max\ (0.min\ (5.5-(Distance\ /max\ Distance)\times 5))/16)$

Each participant can have a minimum score of 0 points and a maximum score of 20 points.Therefore, via the scores obtained for each situation, there is a description for each rating that reflects the participant's behavior toward the stated item (Table 5).

Table 5.
Score descriptions and meanings.

Awarded Score	Description and meaning
5 points	Identical to the correct answer
4 points	Slightly different but shows adequate understanding
3 points	Similarities with errors
2 points	Quite remote but with partial understanding
1 point	Significantly different, revealing limited understanding
0 points	Incorrect and completely different from the correct answer

3.4.6. Step 5 Stage 6: Conducting the Pilot Study

After receiving the necessary ethical approval to conduct our pilot study, we administered the test to a small group of adolescents, comprising 35 participants, in strict compliance with established ethical protocols. Our main objective was to identify any potential difficulties concerning comprehension, question wording or the logistics of administering the questionnaire. We then carefully analyzed the results of the pilot questionnaire, using psychometric measures to assess its reliability and validity.

Following these assessments and in collaboration with experts in the field, we made the necessary adjustments. These modifications were made both to the scenarios presented and to the items themselves.

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More specifically, we corrected certain scenarios and questions to strengthen the test's validity, ensuring a better match between the questions asked and the skills measured. These adjustments increased the questionnaire's reliability coefficient from 75% to 89%, with a significance grade of $p < 0.05$ [29].

4. Analysis and Interpretation

4.1.Descriptive Data Analysis

The test was administered to a larger sample of participants in compliance with the ethical approval obtained for the final study. Importantly, administration procedures were standardized to ensure consistency of results, with an administration guide governing the process wherever it was carried out.The aim was to confirm the validity of the test as a tool for measuring.

4.2. Sample Sociodemographic Data

The stratified sample comprises 378 Moroccan teenagers, with a relatively balanced distribution between the two grade s: 48.3% in second grade and 51.7% in third grade. It is predominantly urban (65.7%), with an almost balanced gender distribution (50.1% girls). These characteristics are taken into account when analyzing the survey results, as they may influence participants' perspectives and behaviors (Table 6).

Table 6.
Distribution of the study sample by environment, grade level, age, and gender (N = 378)

Variable	Category	2nd College year	3rd College year	Total
Environment	Rural	28.4% (107)	39.8% (150)	34.3% (130)
	Urbain	71.6% (271)	60.2% (228)	65.7% (248)
Age	13 Years	89.6% (339)	2.4% (9)	59.6% (225)
	14 Years	9.3% (35)	79.7% (301)	34.6% (131)
	15 Years	1.1% (4)	15.3% (58)	3.4% (13)
	16 Years	0.0% (0)	2.6% (10)	2.4% (9)
Gender	Boys	51.9% (196)	48.0% (181)	49.9% (189)
	Girls	48.1% (182)	52.0% (197)	50.0% (189)
Total		48.3% (183)	51.7% (195)	N = 378

4.3.Descriptive Sampling Data by Type of education

The breakdown of surveyed school-going adolescents (N=378) by type of education shows that in the second year of secondary school, 71.6% of students are enrolled in public schools, whereas 28.4% attend private schools. In the 3rd year of secondary school, 67.3% of students are enrolled in public schools, and 32.7% are enrolled in private schools. Overall, 69.4% of the adolescents were enrolled in the public sector, and 30.6% were enrolled in the private sector (Table 7).

Table 7.
Distribution of students by grade level and type of education (N = 378).

Grade level	Public education	Private education	Total
2nd college year	71.6% (136)	28.4% (54)	100% (190)
3rd college year	67.3% (126)	32.7% (62)	100% (188)
Total	69.4% (262)	30.6% (116)	100% (378)

4.4. Analytical Analysis of Results

The participants' responses were analyzed to confirm the validity of the test as a measurement tool for assessing the impact of integrated nutrition education into life science learning on adolescent behavior.First, we tested the normality and homogeneity of the distribution of scores obtained from the whole sample according to the cognitive domains targeted.

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4.4.1. Normality Test

The statistical data show that the distribution of total scores obtained by the participants, by answering the items of the proposed situations, follows a normal distribution ($p = 0.2 > 0.05$) (Table 8).

Table 8.
The statistical results of the normality test.

N=378	Kolmogorov–Smirnov		
	Statistics	ddl	Sig.
Total score (Cognitive skills)	0.039	378	0.200

4.4.2. Variance Homogeneity Test

Analysis of the data collected on participants' total scores from the homogeneity questionnaire revealed a significant degree of variance in scores based on school grade (second year of college or third year of college) ($p = 0.001 < 0.05$). Furthermore, the analysis indicated that the distributions of scores based on school type (private or public) and living environment (rural or urban) exhibited statistically similar variances, with significance levels of $p = 0.83 > 0.05$ and $p = 0.18 > 0.05$, respectively. (Table 9).

Table 9.
The statistical results of the homogeneity test

N=378		Levene's test	ddl1	ddl2	Sig.
Total scores	School grade	16.994	1	0.001	0.001
	School type	0.043	1	0.837	0.837
	Environment	1.808	1	0.180	0.180

4.4.3.Internal Consistency of the Questionnaire

To check the validity of the scale of items in each test situation, the data collected were analyzed via Cronbach's alpha test. The results obtained show high reliability ($\alpha = 0.89$, $p<0.05$), meaning that the items in the different situations converge toward the same objective.

The high Cronbach's alpha ($\alpha = 0.89$) indicates excellent internal consistency, suggesting the test reliably measures the intended domains. The significant p-value ($p < 0.05$) confirms the impact of educational level on test scores, underscoring the relevance of the intervention.

The test as a whole has a high grade of internal consistency (Table 10).

Table 10.
Statistical results of the internal consistency of the test.

Cronbach's Alpha	Cronbach's Alpha based on standardized items	Number of items
0.896	0.898	64

On the other hand, an evaluation of the effect of each item on the internal consistency of the test reveals that almost all the items contribute to it, confirming their importance in achieving the desired objective.The table below shows the variations in Cronbach's alpha when each item is deleted in the four targeted cognitive domains.

- *Area 1: Food moderation (Table 11)*

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Table 11.
The dietary moderation domain on the internal consistency of the test

Cognitive domain	Cognitive subdomain	Target behavioral competencies	The situations	Number of items (N=16)	Cronbach's Alpha for item deletion	Target domain Cronbach's Alpha (N=378)
Food Moderation	Calorie management	Decision-making	Situation1	Item1	0.96	**0.98**
				Item2	0.97	
				Item3	0.97	
				Item4	0.95	
	Intuitive power supply	Critical thinking	Situation2	Item5	0.97	
				Item6	0.97	
				Item7	0.97	
				Item8	0.97	
	Portion control	Psychosocial	Situation 3	Item9	0.97	
				Item10	0.97	
				Item11	0.97	
				Item12	0.96	
	Meal frequency	Integrative thinking	Situation 4	Item13	0.97	
				Item14	0.98	
				Item15	0.97	
				Item16	0.97	

The majority of items in the dietary moderation domain enhance internal consistency. However, item 14 seems to have no effect on consistency in the cognitive domain of dietary moderation. Element 4 plays a crucial role, as it contributes the most to the internal consistency of this domain.

- Area 2: Food Choices (Table 12).

Table 12.
Effect of food choice items on test internal consistency.

Cognitive domain	Cognitive subdomain	Target behavioral competencies	The situations	Number of items (N=16)	Cronbach's Alpha for item deletion	Target domain Cronbach's Alpha (N=378)
Food Choice	Culture and tradition	Decision-making	Situation 5	Item17	0.87	**0.87**
				Item18	0.85	
				Item19	0.86	
				Item20	0.85	
	Advertising and marketing	Critical thinking	Situation 6	Item21	0.86	
				Item22	0.86	
				Item23	0.87	
				Item24	0.85	
	Psycho-Emotional	Psychosocial	Situation 7	Item25	0.87	
				Item26	0.86	
				Item27	0.87	
				Item28	0.84	
	Hydration and individual needs	Integrative thinking	Situation 8	Item29	0.86	
				Item30	0.85	
				Item31	0.86	
				Item32	0.85	

Similarly, in the food choices domain, analysis of the data collected reveals that almost all the items in this domain contribute to strengthening its internal coherence, with the exception of items 17,23, 25

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and 27, which have no effect on this coherence. Element 28 is considered the most important for the internal coherence of this domain.

- Area 3: Food Preferences (Table 13).

Table 13.
Effect of food preference items on test internal consistency.

Cognitive domain	Cognitive subdomain	Target behavioral competencies	The situations	Number of items (N=16)	Cronbach's Alpha for item deletion	Target domain Cronbach's Alpha (N=378)
Food preferences	Sensory nutrition	Decision-making	Situation 9	Item33	0.82	0.83
				Item34	0.81	
				Item35	0.81	
				Item36	0.82	
	Processed foods	Critical thinking	Situation 10	Item37	0.81	
				Item38	0.81	
				Item39	0.82	
				Item40	0.81	
	Positive environment	Psychosocial	Situation 11	Item41	0.80	
				Item42	0.82	
				Item43	0.82	
				Item44	0.81	
	Modeling (Pair - Parents)	Integrative thinking	Situation 12	Item45	0.83	
				Item46	0.85	
				Item47	0.81	
				Item48	0.82	

The Food Preferences domain demonstrates excellent internal consistency ($\alpha = 0.83$), confirming that all 16 items reliably measure this construct. The four subdomains (Sensory Nutrition, Processed Foods, Positive Environment, Parental Modeling) contribute to this reliability, with stable Alpha values (0.80 - 0.82) upon individual item deletion. Item46 (Parental Modeling) stands out negatively: its removal increases Alpha to 0.85, suggesting potential conceptual misalignment (redundancy, ambiguity, or divergence from the core construct). Conversely, Item41 (Positive Environment) is among the most consistent: its deletion reduces Alpha to 0.80, highlighting its critical role in reliability. Item45 (Parental Modeling) exhibits a neutral effect: its exclusion does not alter the global Alpha (0.83), indicating a standard contribution. While Item46 warrants an in-depth conceptual review for theoretical alignment, the scale remains robust and valid for assessing food preferences, requiring no priority modifications.

- Doamine4: Well-being, Health and Food (Table 14).

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Table 14.
Effect of items assessing the well-being, health and nutrition domains on the internal consistency of the test.

Cognitive domain	Cognitive subdomain	Target behavioral competencies	The situations	Number of items (N=16)	Cronbach's Alpha for item deletion	Target domain Cronbach's Alpha (N=378)
Wellness, Health and Nutrition	Health and nutrition	Decision-making	Situation 13	Item49	0.85	**0.85**
				Item50	0.85	
				Item51	0.83	
				Item52	0.83	
	Technology and snacking	Critical thinking	Situation 14	Item53	0.86	
				Item54	0.84	
				Item55	0.82	
				Item56	0.84	
	Sleep and diet	Psychosocial	Situation 15	Item57	0.84	
				Item58	0.83	
				Item59	0.3	
				Item60	0.83	
	Physical activity and diet	Integrative thinking	Situation 16	Item61	0.83	
				Item62	0.84	
				Item63	0.83	
				Item64	0.83	

Analysis of the data reveals that almost all the items in this domain contribute positively to its internal consistency. However, we noted that item 53 has a negative effect on this coherence. On the other hand, we found that item 55 represents the most relevant element for ensuring this coherence.

4.4.4. Exploratory Factor Analysis of Questionnaires

To verify construct validity, we carried out an exploratory factor analysis, which enabled us to identify the factors explaining the variance in scores between participants. The data collected showed good sampling quality, with a KMO index equal to 0.80 ($P < 0.05$). Interpretation of the factors shows that items within the same factor seem to share the same concept. In fact, the results obtained show the following:

- The items in the first factor, dietary moderation, explained 37% of the variance in scores.
- The items in the second factor, food choice, explained 29% of the variance in scores.
- The items in the third factor, Food preferences, explained 22% of the variance in scores.
- The items in the fourth factor, well-being, health and diet, explained 12% of the variance in scores.When we compare the empirical weights of the factors explaining the variance in the scores obtained by the participants with the theoretical weights predefined in the questionnaire's frame of reference, we note a discrepancy, especially in the first and fourth factors (Figure 7).

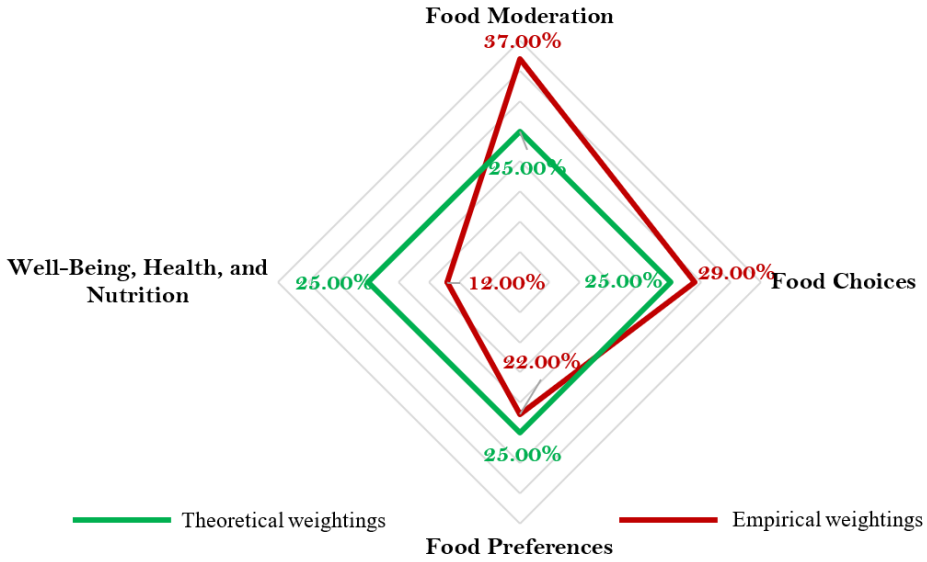

Figure 7.
Comparison between the desired weights of the target cognitive domains and those obtained in this study.

5. Discussion of Results

Test design and validation are essential to ensure the reliability and representativeness of the results obtained from the target population. Studies have shown that unvalidated questionnaires can lead to measurement errors and erroneous conclusions [30].

To assess the effectiveness of nutrition education on adolescent eating behavior, it is crucial to design and validate a suitable questionnaire. The results obtained generally confirm the experts' recommendations.

Indeed, the psychometric indices of the items are often well correlated in each target domain, irrespective of the weighting of factors that might explain the variance in participants' scores. This correlation indicates adequate representativeness of all the cognitive domains and subdomains, reinforcing facial validity. Thus, to obtain a comprehensive understanding of the data [31], we combined the qualitative and quantitative approaches in our data analysis, which confirmed the questionnaire's validity. This validation suggests that the test appears to cover all the necessary areas. We could say that the test developed guarantees both coverage and representativeness from a psychometric point of view.

The interpretation of psychometric data concerning construct validity reveals a high degree of internal consistency within each dimension. This consistency is assessed via methods such as factor analysis, which statistically groups the variables of an instrument to make them more interpretable and usable.

Analysis of psychometric data concerning construct validity reveals significant internal consistency within each dimension. This consistency is assessed through methods such as factor analysis, which statistically groups the variables of an instrument to make them more interpretable and usable [32]. Internal consistency is essential to ensure that test items actually measure the domains they are designed to assess, which is one of the fundamental conditions for satisfactory construct validity.

If we consider that the total score obtained truly provides clues about teenagers' eating behavior, we sought to establish correlations between this score and the scores in each domain. We found that there was a positive correlation, with differences between the domains. Overall, the two dimensions "food moderation" and "food choice" are the most correlated, with Pearson correlation indices of 0.67 and 0.66, respectively ($p < 0.001$). In contrast, the other two dimensions, "food preferences" and "well-being, health

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and diet", had relatively low Pearson correlation indices of 0.46 and 0.43, respectively ($p < 0.001$) (Figure 8).

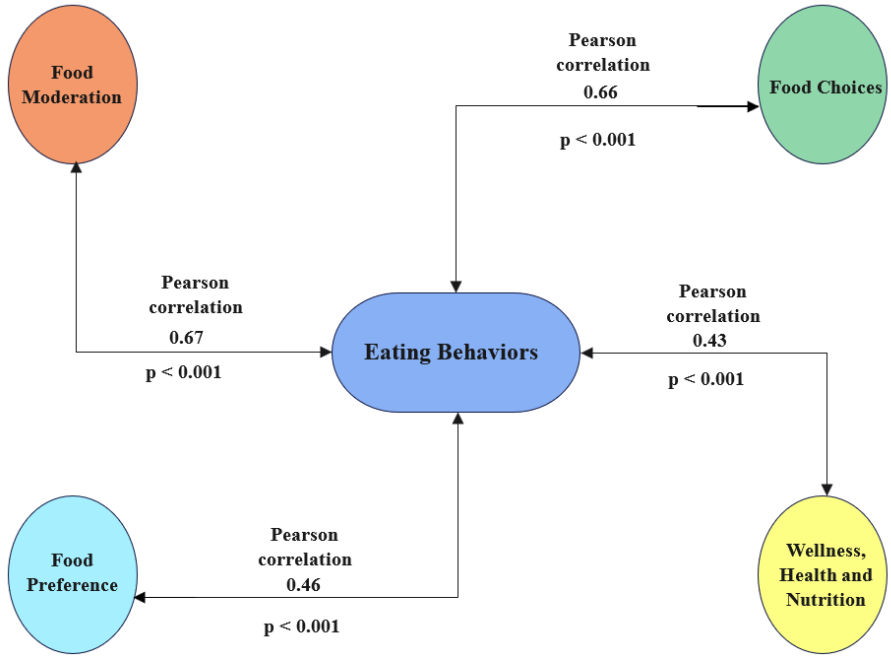

Figure 8.
Correlation between total score and scores in each target cognitive domain.

6. Study limitations

To ensure the reliability of the results obtained, the use of this test requires certain methodological conditions. First, a standardized administration guide is essential to ensure uniformity in test conditions and minimize potential biases. Second, the study should include two distinct groups: an experimental group, which will receive nutrition education, and a control group, which will not be exposed to this instruction. This distinction allows for the specific effects of nutrition education on dietary behaviors to be measured. Additionally, the assessment should be conducted at two points in time before and after the educational intervention to capture changes and evaluate the impact longitudinally.

7. Conclusion

The The study emphasizes the importance of a reliable assessment tool for evaluating the effectiveness of nutrition education integrated into life science curricula. By measuring the impact of these programs, educators can tailor their teaching methods and policymakers can develop more effective public health policies. The study's findings provide valuable insights for improving nutrition education in Morocco and potentially other similar contexts.

The test developed in this study offers a rigorous and validated tool for assessing the effectiveness of nutrition education. It helps identify the strengths and weaknesses of current programs, allowing for targeted improvements and contributing to the prevention of chronic diseases like obesity and diabetes.

8. Policy Implications

Based on the research findings, the following policy implications can be derived:

1. Integrate Nutrition Education into Curricula: Ensure the curriculum covers a wide range of topics, including diet control, food selection, taste preferences, and general health and well-being.

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2. Provide Teacher Training: Equip teachers with specialized training in nutrition education to effectively deliver the curriculum.
3. Implement Standardized Assessments: Use standardized assessments to measure the effectiveness of nutrition education programs and identify areas for improvement.
4. Foster Collaboration and Research: Encourage collaboration between education departments, health ministries, and community organizations to develop comprehensive nutrition education programs. Support ongoing research to inform policy development and improve these programs.

By implementing these policy implications, policymakers can contribute to improving the health and well-being of school-aged adolescents in Morocco through effective nutrition education.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

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