DOI: https://doi.org/10.54393/df.v6i4.185

DIET FACTOR
Journal of Nutritional & Food Sciences
https://www.dietfactor.com.pk/index.php/df
ISSN (E): 2789-8105, (P): 2789-8091
Volume 6, Issue 4 (Oct-Dec 2025)

Original Article

OPEN ACCESS

Integration of Nutrition into the Mathematics Curriculum of Primary Schools in Khyber Pakhtunkhwa: A Quasi-Experimental Study

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ARTICLE INFO

Keywords:
Malnutrition, Primary School Curriculum, Nutrition Integration, Mathematics

How to Cite:
Alam, I. (2025). Integration of Nutrition into the Mathematics Curriculum of Primary Schools in Khyber Pakhtunkhwa: A Quasi-Experimental Study: Integration of Nutrition into the Mathematics Curriculum of Primary School. DIET FACTOR (Journal of Nutritional and Food Sciences), 6(4), 14-18. https://doi.org/10.54393/df.v6i4.185

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Received Date: 5th September, 2025
Revised Date: 20th October, 2025
Acceptance Date: 3rd November, 2025
Published Date: 31st December, 2025

ABSTRACT

Malnutrition and unsuitable dietary habits remain an issue of high priority among the primary school students in Khyber Pakhtunkhwa (KP), Pakistan. Children in this region often lack adequate awareness about healthy eating patterns, and schools rarely integrate nutrition concepts into academic subjects. **Objectives:** To assess not only the role of nutrition education as a supplement in regular curricula (mathematics) but also their learning outcomes (mathematical and nutrition-related knowledge). **Methods:** A quasi-experimental design was implemented with a total of 240 participants (grades 3–5, ages 8–11 years) in eight primary schools (four interventions, four controls). The intervention group was exposed to mathematics with built-in nutrition material for 12 weeks, whereas the control group pursued the normal curriculum. Validated scales of mathematics achievement and nutrition knowledge were used in conducting pre- and post-tests. The data were analyzed with paired and independent t-tests. **Results:** The data did not show any differences between groups in terms of baseline. Nevertheless, after the intervention, analysis showed that both mathematics performance (mean change: 14.2 ± 5.1 in intervention vs. 5.1 ± 4.9 in control, $p<0.001$) and nutrition knowledge (mean change: 12.6 ± 4.3 in intervention vs. 2.3 ± 3.8 in control, $p<0.001$) had improved significantly. **Conclusions:** The inclusion of nutrition concepts into the mathematics curriculum was also a significant contributor to improvement in mathematics and nutrition awareness following the implementation of the concept in KP primary school students.

INTRODUCTION

Child nutrition is one of the most important aspects in cognitive development, concentration in the classroom, and general academic performance, and its relationship with education and health cannot be ignored [1, 2]. Nutrition in school children not only helps in physical development, but also in the optimum development of the brain, retaining skills and capacity to learn [3]. On the other hand, deficiencies and undernutrition of micronutrients have been demonstrated to affect attention, memory, and performance in academic work, resulting in end-of-term deficits in academic achievements. Malnutrition is one of the most long-standing public health issues in Pakistan and among school-going children in Khyber Pakhtunkhwa (KP). In the recent national nutrition survey reports [4, 5], stunting, underweight, and iron, vitamin A, and calcium deficiencies are alarmingly high. These nutritional deficiencies result in a vicious circle of underachievement in school, low productivity, and reduced human capital development in the province. Schools are a perfect and fair way of health promotion and avoiding malnutrition since they access children at a tender age and offer constant exposure to educational settings [6]. Nevertheless, in Pakistan (as in many other low- and middle-income countries), nutrition education is commonly taught as an independent, health-related course, without being linked to major academic courses. Such a disjointed method

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limits the support of essential health concepts and tends to be in conflict with other academic priorities, resulting in decreased student engagement and retention. Curriculum integration has been identified as a potential solution to these issues, in which the concepts of nutrition are incorporated into the normal school courses like mathematics, language, or social studies [7-9]. As an illustration, students can be taught fractions by ending up with food parts, percentages by nutrient composition, and data analysis by collecting food frequency surveys. This kind of combining gives a two-fold benefit of not only improving academic but also health literacy outcomes because it enhances contextual learning, interdisciplinary thinking, and good use of time within the current activities of the classrooms. International research demonstrates that cross-curricular integration enhances and improves knowledge retention, problem-solving skills, and higher-order thinking, while also increasing motivation and student engagement through practical application. This is particularly applicable in the case of the Education Sector Plan of Khyber Pakhtunkhwa, where the focus is on enhancing literacy and numeracy, as well as forming a multi-sectoral coalition to improve nutrition and health outcomes [10, 11]. The importance of the study is that it presents empirical data on the relationship between curriculum integration as a dual-purpose innovation in education in Pakistan as a means of improving the academic performance of students and increasing the necessary health knowledge. This study will contribute to the policy debate on integrated education and child development in low-resource contexts by showing a practical, contextually dynamic example.

The present study aimed to evaluate the effectiveness of teaching mathematics using a mathematics education curriculum with the inclusion of a nutrition education curriculum to determine mathematics achievement and nutrition literacy levels among primary school children in Khyber Pakhtunkhwa.

METHODS

A quasi-experimental study, following a pretest-posttest control group design, was conducted from September to December 2024 on eight randomly selected government primary schools located in Charsadda and Mardan districts of Khyber Pakhtunkhwa. The study included 240 students from grades 3—5 (aged 8—11 years), divided equally into intervention (n=120) and control (n=120) groups. Schools were selected using a cluster random sampling method. First, a list of all public primary schools in the two districts was obtained. From this list, schools were eligible if they were (a) mixed-gender, (b) located in a semi-urban area, and (c) not currently running any other formal nutrition program. Eight schools that passed these criteria were randomly chosen (with the aid of a random number sequence, which was generated on a computer) and randomly put in either the intervention or control group. The a priori determination of the sample size was conducted with the help of G*Power software. The power was calculated with 0.05 alpha (a), power (1- 5) = 0.80, and medium effect size (Cohen d = 0.5), which were based on the previous educational research done with interventions. This analysis meant that the necessary overall sample size was about 210, and it was planned to have a group of 240 so that the possibility of the loss of participants could be considered, as well as it would help to strengthen the results. Written informed consent was taken. The intervention group received 12 weeks of mathematics lessons, and nutrition education about fractions as portions, percentages, and measures as food volumes, and data analysis using food frequency surveys. The intervention schools involved the teachers in two days of training on the integrated pedagogy, as compared to the control schools that used the standard mathematics curriculum. The evaluation was conducted using two instruments that were previously tested and validated (30-item Mathematics Achievement Test (Cronbach 83) and 25-item Nutrition Knowledge Questionnaire (Cronbach 79)) and created and tested among primary school students in Pakistan. These scale instruments have been constructed and tested on a pilot sample of a different group of primary school students of the same demographic. Construct validity was determined by subjecting the items to a panel of five experts in education and nutrition, and making sure that the items were appropriate to measure the curriculum and important areas of knowledge. The instruments were then piloted, and a two-week test-retest reliability analysis showed strong stability (Intraclass Correlation Coefficient (ICC) = 0.85 for the Mathematics Test and ICC = 0.81 for the Nutrition Questionnaire). The changes in mathematical performance and nutrition knowledge were measured by the use of pre- and post-tests. Digital data on baseline demographics and diet were obtained via structured questionnaires. Analysis of data was done using SPSS version 26.0. The assumption of normality for the pre-post change scores was assessed and confirmed using the Shapiro-Wilk test ($p>0.05$ for both groups on both outcome measures). Changes were compared using paired t-tests between pre- and post-intervention change within the groups and independent t-tests between the groups. The residuals from the ANCOVA models were also checked and met the assumptions of normality and homogeneity of variances.

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RESULTS

The framework for integrating nutrition into the primary school mathematics curriculum was analyzed (Table 1).

Table 1: Framework for Integrating Nutrition into Primary School Mathematics Curriculum

Mathematics Concept	Nutrition Theme	Classroom Activity Example	Expected Learning Outcome
Fractions (½, ¼, ⅓)	Portion sizes and balanced meals	Use a roti or an apple to show halves and quarters while discussing meal portions.	Students understand fractions and balanced meal portions
Percentages (%)	Daily nutrient requirements	Calculate % of daily calcium from a glass of milk	Students apply percentage concepts to real-life nutrition
Addition and Subtraction	Food groups and variety	Add or remove food items (lentils, vegetables, rice) to form balanced meals.	Students enhance arithmetic skills with nutrition awareness
Measurement (grams, kg)	Food quantities and weights	Weigh rice, lentils, or flour to learn measurement units	Students relate measurement to real food quantities
Geometry (shapes, area)	Food shapes	Identify shapes of roti, bread, or samosa and calculate area/perimeter	Students associate geometry with familiar food items
Data Handling (graphs, charts)	Dietary diversity	Survey favorite fruits and create bar/pie charts	Students learn data representation through dietary habits
Ratios & Proportions	Balanced diet plate	Express healthy plate in ratio (2:1:1 for veg: protein: grains)	Students understand ratios and balanced diet composition

Baseline characteristics of participants in the intervention (n=121) and control (n=119) groups. The p-value was determined as less than 0.05. No significant differences were observed between the two groups in terms of age, gender distribution, baseline mathematics scores, or baseline nutrition knowledge ($p > 0.05$), indicating that both groups were comparable at the start of the study (Table 2).

Table 2: Baseline Characteristics of Participants (n=240)

Variables	Intervention (n=121)	Control (n=119)	p-Value
Age (Years, Mean ± SD)	9.4 ± 0.8	9.3 ± 0.7	0.41
Gender (Male, %)	55 (45.8%)	58 (48.3%)	0.72
Baseline Math Score	48.6 ± 9.2	47.9 ± 9.5	0.63
Baseline Nutrition Knowledge	21.1 ± 5.6	20.7 ± 5.8	0.58

Post-intervention results showed significant improvement in both mathematics performance and nutrition knowledge among students taught with the integrated curriculum. ANCOVA, adjusting for baseline scores, age, gender, and socioeconomic status, confirmed a statistically significant effect of the intervention on both post-intervention mathematics scores ($F(1,234) < 0.001$) and nutrition knowledge scores ($F(1, 234) = 0.001$). After 12 weeks, the intervention group demonstrated higher gains in mathematics (14.2 ± 5.1 vs. 5.1 ± 4.9) and nutrition knowledge (12.6 ± 4.3 vs. 2.3 ± 3.8) compared to the control group ($p<0.001$) (Table 3).

Table 3: Post-Intervention Outcomes

Outcomes	Intervention (n=121)	Control (n=119)	Mean Difference	p-Value
Math Score Improvement	14.2 ± 5.1	5.1 ± 4.9	9.1	<0.001
Nutrition Knowledge Improvement	12.6 ± 4.3	2.3 ± 3.8	10.3	<0.001

DISCUSSION

The intervention and control groups were similar at baseline in terms of demographics and academics. In the intervention group, 45.8% of the males and 48.3% in the control group ($p=0.72$). There were no significant differences observed in baseline scores of mathematics and nutrition knowledge, which means that there was comparability between the cohorts and minimal baseline confounding. Looking at the post-intervention scores of both groups in mathematics and nutrition knowledge, both groups demonstrated improved scores, but the intervention group demonstrated significantly better improvement. Table 2 revealed that the mathematics scores improved in the intervention group by 14.2 and 5.1 as compared to the control group by 5.1, respectively, with a mean difference of 9.1. Likewise, the difference in interventions between the intervention group and the control group in terms of nutrition knowledge improved by 12.6 and 2.3 points, respectively, and the difference is significant ($p<0.001$), indicating the effectiveness of the integrated curriculum. Subgroup analyses, both gender-wise and grade-wise, did not find any significant differences, indicating that the intervention was effective with both boys and girls and Grades 3-5. This homogeneity favors the homogeneity of the integrated approach to other levels of primary schools in Khyber Pakhtunkhwa. The current investigation is a successful demonstration of the fact that incorporating mathematics classes with nutrition concepts will improve academic knowledge and health literacy. This observation is consistent with available global research on the topic, which has shown that cross-curricular integration leads to better student engagement, understanding, and retention [12-14].

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Believing that active learning with real-life nutrition problems improved mathematical reasoning is plausible since the contextualized cases are easier to comprehend and solve problems [15, 16]. Similarly, repeated access to nutrition education throughout lessons will support the maintenance of knowledge and promote healthier attitudes, which is in line with the earlier educational interventions that associate classroom exposure with better health-related behaviors [17, 18]. The tools of the research, which were utilized in the study, were contextually valid and sound, including the Mathematics Achievement Test and the Nutrition Knowledge Questionnaire, with Cronbach 0.83 and 0.79 internal consistency respectively. Self-reported nutrition data, short intervention, and school participation were also weaknesses of it and had some implications in terms of generalizability. All in all, the findings suggest that mathematics lesson nutrition is a cost-effective, simple-to-use, and scalable intervention to enhance the academic performance and the health literacy level of primary students in Pakhtunkhwa. This study warrants the implementation of multi-sectoral nutrition policy at the policy level in line with integrated pedagogic practices in Khyber Pakhtunkhwa [19, 20]. The subsequent research must be aimed at measuring long-term results, professional training requirements, and institutional viability to make it sustainable.

CONCLUSIONS

The integration of nutrition education in the math curriculum enhanced both math achievement and nutrition knowledge among children in KP's primary schools. This innovative, low-cost strategy could be replicated throughout the province to address educational and health issues simultaneously.

Authors Contribution

Conceptualization: IA
Methodology: IA
Formal analysis: IA
Writing review and editing: IA

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

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