Effect of Project-Based Learning in Learners' Nutrition Knowledge in Secondary Schools in Central Uganda

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ABSTRACT
In Uganda, the Nutrition and Food Technology (NFT) subject is taught to teach learners about healthy eating and lifestyle choices through active teaching methodologies such as project-based learning (PBL). This study aimed to improve nutrition knowledge among secondary school students in Uganda using PBL. The study was implemented using an embedded mixed methods design in which convergent parallel mixed methods design was nested within Solomon's four-group, quasi-experimental design. The study showed that compared to the control group, PBL implemented following the PBLWorks model increases the nutrition knowledge of learners indicated by a significant increase in the diversity of foods on their meal plans (Mean difference = 1.16; U(115) = 954, p = < .001), the frequency of planned consumption of vitamin A-rich foods (Mean difference = 1.3; t(115) = 3.41, p = < .001), planned consumption of Haem iron-rich foods (Mean difference = 1.6; t(115) = 3.24, p = 0.002), NCD protect scores (Mean difference = 1.65; t(115) = 3.15, p = .000), and food consumption scores (Mean difference = 18.7; t(115) = 7.42, p = < .001). However, the study was limited to Kampala, so further research across the country is recommended.

Keywords: PBLWorks model, Nutrition and Food Technology, project-based, learning, learners, school

BACKGROUND OF THE STUDY

Teaching and learning of nutrition knowledge in schools started in the 1800s in the USA and Europe [1, 2]. For example, public schools in Boston started teaching nutrition in 1872 when the Massachusetts legislature passed an act that made domestic science and other industrial education subjects legal throughout the state [2]. Also, European countries like Germany, France, and the United Kingdom started offering nutrition education in their schools in the middle of the 19th century [1]. Learning of nutrition was accentuated by the fact that by the 19th Century, developed countries like the USA and Europe experienced an industrial revolution leading to unprecedented increasing rates of overweight, obesity, and non-communicable diseases due to increased consumption of processed grains and sugar [3]. The literature does not mention the pedagogies used in learning nutrition knowledge then.

In Africa, the subject was introduced along with colonialism in different countries [4] because the colonialists were coming from countries already offering the subject. In Kenya for example, it was started as a girls' subject known as domestic science around 1904 by wives of British missionaries utilizing a British-based curriculum [2]. In Zambia, the missionaries introduced Nutrition education in schools in

1915 as a practical subject for girls but mostly focused on home crafts and mother craft [4] and taught through 'hands-on'. Then, in Botswana, it started as early as the 1920s by missionaries as a stereotypical housewife extracurricular activity that was later named domestic science and then home economics with majorly foreign content [5]. Similarly, in Uganda, it started in 1905 at Gayaza High School as a subject to educate daughters of kings and prominent chiefs on domestic chores such as cooking [6]. This shows that at the introduction of this subject in the colonial states, its curriculum was dependent on the colonial masters. Other than 'hands-on' as a method, no other methods of teaching were reported.

In Uganda, this subject has metamorphosed from the colonial domestic science to early post-colonial home economics and needlework [7], to independent subjects of foods and nutrition, home management, clothing, and textiles [8] to now Nutrition and Food Technology [9]. In the revised lower secondary school curriculum for Uganda, home management as well as clothing and textiles were left out and the content for foods and nutrition was re-worked to meet the new societal needs especially combating malnutrition, post-harvest handling of food and food processing [9, 10]. For over the last 50 years, the subject has predominantly been taught through teacher-centered pedagogies [9] and this has been cited as a cause of low nutrition knowledge [11-13].

Despite nutrition education being done in schools in Uganda, studies have revealed that 49.9%-54% of secondary school students in Uganda have poor nutrition knowledge [14, 15]. This has majorly been attributed to the predominant use of teacher-centered pedagogies [11-13, 16-20]. Consequently, there is lack of understanding of essential nutrition concepts, such as balanced diets, the nutritional value of foods, dietary guidelines, and the link between nutrition and health [12, 21]. Unlike other teaching methods like group work, role plays, etc., Project-based Learning (PBL) is the broadest and has been mooted in other disciplines as most effective at promoting deep learning in other disciplines [22, 23] especially for learners with an internal locus of control who believe they have full charge of their process of learning and its outcomes [24]. it is not yet clear how PBL enhances understanding of nutrition knowledge. Hence, there is a vacuum of empirical evidence on the role of PBL in developing an understanding of nutritional knowledge. The purpose of this study therefore was to explore the effect of the PBLWorks model on the development of nutrition knowledge of secondary school learners in Uganda.

Theoretical perspective

The study was guided by the Buck Institute of Education's Problem Based Learning (PBL) Works model [25] and Vygotsky's social learning theory [26]. The PBLWorks model provides a structural breakdown of activities that should be carried out by teachers during PBL. The PBLWorks model has been used to improve learning outcomes in reading, mathematics, history, and chemistry [27, 28]. Furthermore, the focus of the studies on the effectiveness of the PBLWorks model in improving learning outcomes was not Nutrition and Food Technology or subjects of related nomenclature. Since teaching and learning are entangled, to understand learning during PBL from the perspective of the learner, Vygotsky's social learning theory [26] was used to augment the PBLWorks model. Vygotsky's social learning theory was deemed fit because project-based learning offers an opportunity for learners to share knowledge through social setting of groups [25]. The social learning theory emphasizes that during learning activity, learners should be scaffolded through the Zone of Proximal Development (ZPD) as they progress from what they already know or can do without assistance to what they can do with a more knowledgeable other [26]. During the process, learners are expected to take responsibility for their learning with limited support from a teacher or more knowledgeable peer [29]. This applies to project-based learning because PBL is often implemented in groupwork where learners benefit from guidance of others with better experiences.

METHODOLOGY

Study design

This study was guided by the pragmatism research paradigm and was implemented using an embedded mixed methods design in which convergent parallel mixed methods design was nested within Solomon's four-group, quasi-experimental design [30, 31]. During the study, one group of learners received a pre-test, an intervention, and a post-test. The second group in a different school received an intervention and post-test with no pretest. The third group in another school received a pretest and post-test without the intervention and the fourth group received only a post-test as summarized in Table 3.1.

Table 3. 1: Summary of Solomon's four-group design experimental setup used in the study

School	Pretest	Intervention		Post-test
A (n = 110)	Yes	Yes		Yes
B (n = 98)	No	Yes		Yes
C (n = 100)	Yes	No		Yes
D (n = 103)	No	No		Yes

[30, 31]

A comparison of schools' C and D results was used to establish if there was a pre-testing effect on learners' results. This was counter-checked by comparing schools A and B. Both intervention and control schools used learning outcomes from the NCDC syllabus extract as shown in Table 3.2 [9]. In the four schools, teachers involved had not previously taught using PBL.

Table 3. 2: Outline of the piloted topic the Nutrition and Food Technology syllabus Senior 1 T erm 1 Theme: Meal management **Periods:** 8

TOPIC: Introduction to Nutrition and Food Technology

Competency: The learner is able to show understanding of cultural differences in food, the link between nutrition and health and the need for hygiene in food preparation and storage

LEARNING OUTCOMES The learner should be able to:	**SUGGESTED LEARNING ACTIVITIES**	**SAMPLE ASSESSMENT STRATEGY**
appreciate the foods of different cultures (k, v) understand the factors that influence feeding habits and practices of people (u) develop a general understanding of key terms used in Nutrition and Food Technology and appreciate the importance of healthy living (k, u)	Learners should be introduced to some foods from different countries and cultures and discuss the differences and the reasons why they vary. They should be shown the different methods of preparation and cooking and try some of these themselves. They should discuss why foods vary around the world. They should be introduced to the impact of food on health and work in groups to devise healthy diets. During these activities, they should be introduced to the key terms of food technology such as:	Observation of learners discussing healthy diets. Conversation about key terms and reasons for cultural differences. Look at the meal plans. (product)

	diet, nutrition & nutrients, malnutrition, over and under-nutrition, food processing and preservation ***Project: Learners set up a disposal unit in the school for easy waste management and write report. (compulsory project)***	

Adapted from the NFT syllabus [9].

Learners in all four schools were taught this first topic extract (Table 3.2). For the three learning outcomes in Table 3.2, learners in the intervention schools were engaged in project-based learning (Appendix 5) using foods of different cultures guided by an assignment question in Table 3.3 which was prior validated by the supervisors and independently reviewed by a group of five high school teachers.

Table 3. 3:Project-based learning assignment question

Some foods are unique to each culture. For instance, in Uganda, the Bagisu eat 'Malewa' (smoked bamboo shoots), the Iteso eat 'Amukeke' (dried slices of sweet potatoes) or 'Emuna' (mix of ghee and groundnut paste), the Langi and Acholi eat 'Malakwang' (Hibiscus vegetable), the Batooro and Banyoro eat 'Firinda' (boiled smashed beans with seed coats removed), and the Bantu-speaking tribes eat 'Nsenene' (edible grasshoppers). It is surprising to learn that people belonging to a particular culture are always proud of the food they eat, which often is regrettably disliked by people who are not part of that society.	
	
Amukeke	**Grasshoppers**
Consider yourself a host of visitors from different cultures in Uganda, make a one-day meal plan, and prepare what you would feed your visitors for breakfast, morning snack, lunch, afternoon snack, and Dinner while considering the link between food and health.	

Meanwhile, those in control schools were engaged in group discussions as per the learner's NFT textbooks (Appendix 6). Also, at the end of the topic, learners in the control schools did the mandatory projects of making a home decoration to bring out the importance of healthy eating as well as setting up a disposal unit in the school for easy waste management all without following the PBLWorks model. Those in the intervention schools did not do these two mandatory projects during the time of this study.

Endline data was then collected three weeks after the intervention period to allow learning of hygiene, the remaining part of the intervention topic that was not relevant to the research, and also not to interrupt the timing of projects at the end of the topic in the control schools. There is no ideal duration between the end of the intervention and the collection of endline data. However, for in-school nutrition interventions across the last two decades, the duration is raging from immediately [32-35] to 1 ½ years [36].

Participants and study setting

Four secondary schools with relatively similar social demographic characteristics were involved. All senior one learners in these schools were involved in the study giving a total of 283 learners of which 17 dropped out during the intervention and control groups during the course of the study leaving 266 for endline assessment. Then, eight teachers, two from each of the four schools were interviewed at the endline. Only five interviews (three from the intervention schools and two from the control schools) were considered due to saturation [37]. In addition, 12 focus group discussions with leaders of project groups were conducted and six were considered for analysis due to data saturation [37]. All senior one learners in the four purposively selected schools were each treated as a cluster and there was no attempt to make selection of learners within the clusters. Teachers of NFT were purposefully recruited for the study and so, only NFT teachers of senior one in each of the designated schools were the ones involved in the study though these teachers were teaching other classes as well. Senior one learners were involved during the intervention because the topic that looks at the diversity of food and the link between nutrition and health is taught in senior one term one [9].

Data Collection

Data was collected both at baseline and endline using a learners' self-administered questionnaire, project group leaders' FGD guides and teachers' key informant interview guides. Data quality control was implemented through a rigorous process prior to, during, and after the collection of quantitative and qualitative data, ensuring comprehensive and accurate results.

Data analysis

Across the three objectives of the study, qualitative data was analyzed by thematic analysis [38] using ATLAS.ti 8. During thematic analysis, six steps were involved and they included familiarization with the data through reading and editing transcripts while listening to the respective audio recordings; then open coding the transcripts in ATLAS.ti 8. This was followed by focused coding of the transcripts guided by the BIE PBLWorks model and study objectives and finally generating subthemes through grouping focused codes. To check the accuracy of the coding, two other PhD learners carried out the procedure separately. Lastly, a written report outlining the themes and a final analysis where the empirical findings were generalized to the theory was done.

In determining the effect of PBL on learning nutrition knowledge among secondary school Analysis of variance (ANOVA) test, independent samples t-tests, dependent samples t-tests, and Mann–Whitney U test were used. Analysis of variance (ANOVA) test was used to check if the study groups had significantly different social demographic characteristics that could have affected the difference in nutrition knowledge. To compare food consumption scores; frequency of vitamin A-rich foods, frequency of Haem iron-rich foods, and frequency of protein-rich foods in meal plans within the experimental and control groups t-tests were used. Finally, the Mann–Whitney U test was used to compare dietary diversity scores between the experimental and control groups because the IDDS data was not normally distributed.

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RESULTS

Socio-demographic characteristics of the participants

All learners in both the intervention and control schools were senior ones and below 20 years old. Almost an equal proportion of males and female learners were involved in the study. The school fees learners paid in term one was on average 2.6 million, and the majority of the learners had passed primary Leaving examinations (PLE) with a first grade. More details on social demographic characteristics of the study participants are summarized in Table 3.1.

Table 3. 1: Social demographic characteristics of the study participants

Background characteristics	Not group leaders (n=197) n (%)			projects' group leaders n = 46 n (%)	teachers of NFT n = 6 n (%)
	Intervention group (n = 73) n (%)	Control group (n = 45) n (%)	F statistic, p-value	Among projects' group leaders n = 21 n (%)	Among teachers of NFT n = 5 n (%)
Gender			χ2 = 1.419; p = 0.701		
Male	34 (46.6)	21 (46.7)		11 (52.4)	1 (20.0)
Female	39 (53.4)	24 (53.3)		10 (47.6)	4 (80.0)
Age (years)					
10-19	73 (100)	45 (100)	F=1.089, p= 0.354	21 (100)	
20-29					1 (20.0)
30-39					2 (40.0)
40-49					2 (40.0)
50-59					
Mean School fees	2690410.96 ±276969.906	2653333.33 ±176583.743	F=2.141, p= 0.095		
Grade at PLE			F= 2.495; p = 0.060		
First grade n (%)	62 (84.9)	35 (77.8)			
Second grade n (%)	11 (15.1)	10 (22.2)			
Teaching experience (Years)					
0-9					2 (40.0)
10-19					1 (20.0)
20-29					2 (40.0)
Highest academic qualification					

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Bachelor's degree					5 (100%)

Source: Primary data

The effect of PBLWorks model on nutrition knowledge

Findings in Figure 4.3 show that at baseline, over 50% of the meal plans were monopolized by cereals, fish, iron-rich organ meats, sweets and spices. Less than 30% of the learners planned for vitamin A-rich vegetables and tubers, dark green leafy vegetables, other vegetables, vitamin A-rich fruits, and red palm products. There was no significant difference in the meal plans of the intervention and control schools. After the intervention, it was observed that there was a significantly greater increase in planning for cereals in the control group (M = 0.18) compared to the PBLWorks group (M = -0.09), t(115) = 2.32, p = 0.02. Additionally, there was a significant reduction in planning for eggs in both the PBLWorks (M = -0.35) and control schools (M = -0.16), although the difference between the study groups was not significant (p > 0.05). Furthermore, there was a significant increase in planning for Vitamin A-rich vegetables and tubers in the PBLWorks group (M = 0.24) compared to the control group (M = 0.02), t(115) = 2.54, p = 0.01. Similarly, there was a significant increase in planning for dark green leafy vegetables in the PBLWorks group (M = 0.37) compared to the control group (M = 0.07), t(115) = 3.00, p = 0.003. Moreover, vitamin A-rich fruits were significantly planned for more in the PBLWorks group (M = 0.52) than in the control group (M = 0.09), t(115) = 3.96, p < 0.001. Additionally, iron-rich organ meats were significantly planned for more in the PBLWorks group (M = 0.32) than the control group (M = 0.02), t(115) = 2.27, p = 0.03. Finally, fish was planned for significantly more in the PBLWorks group (M = 0.49) than the control group (M = 0.24), t(115) = 2.05, p = 0.04.

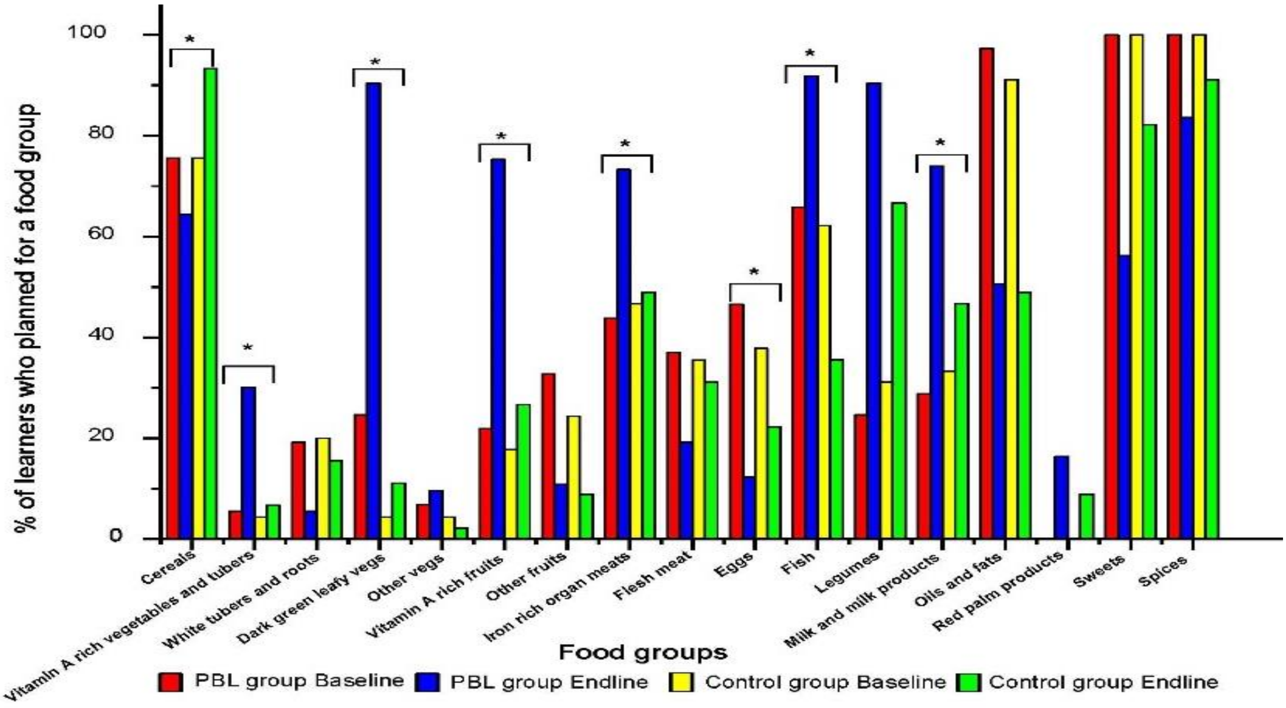

Figure 3.1: Diversity of food groups in the intervention and control schools. A statistically significant difference is represented by * p < 0.05, as determined by Mann–Whitney U

Source: Primary data

Upon amalgamate analysis of food-specific changes, the study found no significant difference in the number of days planned for consuming protein-rich foods between the PBLWorks group and the control group ($p>0.05$). However, participants in the PBLWorks group showed a significantly greater increase in the inclusion of haem iron-rich foods in their meal plans (M = 1.82) compared to the control group (M = 0.22), $t(115) = 3.24$, $p = 0.002$. Additionally, the PBLWorks group planned significantly more for vitamin A-rich foods (M = 0.90) compared to the control group (M = -0.400), $t(115) = 3.41$, $p = < .001$. Furthermore, the individual dietary diversity scores of the meal plans showed a significant increase in the PBLWorks group (M = 0.93) compared to the control group (M = -0.23), $U(115) = 954$, $p = < .001$. The increment in food consumption scores was also significantly higher in the PBLWorks group (M = 17.3) compared to the control group (M = -1.40), $t(115) = 7.42$, $p = < .001$. Likewise, the NCD protect scores showed a significantly greater increase in the PBLWorks group (M = 2.56) than the control group (M = 0.91), $t(115) = 3.15$, $p = .000$. Further details on changes in indicators of learners' nutrition knowledge are presented in Table 4.5.

Table 4. 2: Learners' knowledge of nutrition and health of the intervention and control groups

Variable	**Mean (95% CI)**					
	Intervention group (n = 73 learners)			**Control group** (n = 45 learners)		
	Baseline	Post-intervention	Change	Baseline	Post intervention	Change
Mean number of days food items are planned to be consumed						
Vitamin A-rich foods (Diary, flesh meat, organ meat, Eggs, orange vegetables, and orange fruits)	6.07 (4.51-7.63)	6.96 ^{a} (6.70-7.22)	0.89 ^{a} (-0.67-2.45)	5.64 (3.687.61)	5.24 ^{b} (3.1-7.39)	-0.44 ^{b} (-2.97-2.17)
Protein foods (Pulses, Diary, flesh meat, organ meat, fish and eggs)	7.00 (7.00-7.00)	7.00 (7.00-7.00)	0.00 (0.00-0.00)	7.00 (7.00-7.00)	7.00 (7.00-7.00)	0.00 (0.00-0.00)
Haem iron-rich foods (flesh meat, organ meat, fish)	4.79 (2.84-6.75)	6.60 ^{a} (5.44-7.77)	1.81 ^{a} (-0.50-4.12)	5.09 (3.13-7.05)	5.31 ^{b} (3.45-7.17)	0.22 ^{b} (-2.76-3.21)
Diet quality scores						

Mean dietary diversity score (Mean IDDS)	6.62 (5.40-7.84)	7.90^{a} (6.61-9.19)	1.29^{a} (-0.43-3.01)	6.67 (5.427.92)	6.29^{b} (5.00-7.58)	0.02^{b} (-1.79-1.84)
Mean food consumption score	65.11 (54.10-76.12)	82.52 a (75.28-89.76)	17.41 a (4.03-30.79)	63.09 (52.57-73.61)	61.69 b (53.82-69.55)	-1.40 b (-14.34-11.54)
Mean NCD protect scores	2.40 (0.97-3.83)	4.97^{a} (3.85-6.09)	2.58^{a} (0.91-4.25)	2.16 (0.78-3.54)	3.07^{b} (1.77-4.37)	0.91^{b} (-1.072.89)

For a given experimental stage, Mean values with different superscripts are significantly different from each other at $p < 0.05$.

Source: Primary data

The increased variety of foods and healthier focus in meal plans of learners who used the PBLWorks model compared to the control group is corroborated by knowledge learners articulated they had gained about foods of different cultures in Uganda. A learner in the intervention school revealed that

Before the project, I made a meal plan but I included a lot of tea, eggs, bread, and Samosa for breakfast and then flesh meat, chicken, and pork plus ‘matooke’ [bananas] and ‘Kalo’ [Cassava and/or millet or sorghum bread] for lunch and supper that I kept alternating. During the project, we learned new cultural foods like ‘Amukeke’ [dried sweet potatoes] but I planned for orange-fleshed sweet potatoes ‘Amukeke’ [dried sweet potatoes] pancakes, biscuits, and pizza instead of the white to ensure high vitamin A intake. I also included ‘Boo’ [Sweet pea leaves), ‘Jambula’ [Java plum], ‘Amatuguru’ [Wild red ginger fruit], and ‘Entuutu’ [Cape goose berry] to boost the intake of Vitamin A-rich fruits. I also increased the vegetables in the meal plans by adding traditional ones like ‘Sombe’ [Cassava leaves] and ‘Malakwang’ [Hibiscus], as well as organ meats, to increase the variety of meat types (Intervention school, Std FGD).

Another learner in the intervention school also stated that;

In the beginning, there were foods that I never considered because I didn’t know them. These included ‘Eshabwe’ [Ghee source], ‘Amatuguru’ [Wild red ginger fruit], ‘Mugunu’ [Smashed cassava with beans], ‘Nang-nang’ [African tiger fish], ‘Boo’ [Sweet pea leaves], and ‘Toke’ [Malakwang seeds] (Intervention school, Std FGD).

Furthermore, a learner in another FGD in the intervention school stated

Thank you, teachers, for the projects. I previously didn’t know foods like ‘Otigo’ [Okra], ‘Afoyo’ [White rabbit meat], ‘Amatuguru’ [Wild red ginger fruit], ‘Angara’ [Pebbly Fish], ‘Pedo’ [Paper fish], ‘Anyoya’ [a combination of beans and maize], ‘Coroko’ [Tinny green peas], ‘Ngoo” [Crushed black-eyed peas], ‘Mugoyo’ [Smashed sweet potatoes with beans] and ‘Mugunu’ [Smashed cassava with beans]. I had to include them in my final meal plan (Intervention school, Std FGD).

Similarly, a teacher in the intervention school said that

My learners learned about the food pyramid and MyPlate graphic and that shaped their understanding of a healthy meal plan to constitute of whole grains, tubers, a variety of vegetables, fruits, and animal-source protein foods. This made them reflect on their food choices to include in the meal plans rather than how it was at baseline. So, my learners ended up including in their meal plans foods they had at the beginning as you saw considered disgusting. I have a group that abused their group member whose cultural food ‘Malakwang’ [Hibiscus] was termed as food for Monkeys by her fellow learners who even first refused to work with it. Surprisingly many of the learners in the class by end of the intervention included it in their meal plans. I also noticed a high presence of 'Amukeke' [dried sweet potatoes] products, 'Malewa' [Bamboo shoots], 'Matooke' [Bananas], 'Luwombo' [Meat, Fish in Groundnuts or Chicken steamed in banana leaves], 'Firinda' [smashed beans without Testa], and many other cultural foods in meal plans (Intervention school, Teacher KI).

Meanwhile, a learner in the control school stated that;

We learned that 'Baganda' [tribe in central Uganda] love 'matooke' [Bananas], Banyankore [tribe in Western Uganda] love 'Eshabwe'[Ghee source], Bagisu [tribe in Eastern Uganda] love 'Malewa' [Bamboo shoots], and people from northern Uganda love kalo [millet bread]. So, I tried to put this in the meal plan (Control school, Std FGD).

Relatedly, a teacher in the control school stated that;

I used group work as shown in the learners' book and my learners discussed and presented foods of different cultures like 'Malewa' [Bamboo shoots], 'Luwombo' [Meat, Fish in Groundnuts or Chicken steamed in banana leaves]. I did not focus on meal planning because meal planning is a topic on its own to be covered latter in the syllabus (Control school, Teacher KI).

These findings show that by the end of the intervention duration, learners and teachers in the intervention school were able to mention a greater variety of cultural foods off head showing more knowledge of the diversity of cultural foods and this was reflected in their meal plans as well where a wider range of foods were included subsequently planning for healthier diets with reduced monotony of processed cereals and grains, eggs, and sugar. However, only the first learner planned for foods giving reasons for nutritional benefits. The others didn't bring out the nutritional benefits of their food choices but included foods in meal plans because they learned about foods from different cultures. This shows that teachers need to emphasize more to learners the articulation of the nutritional benefits of food choices. Also, the teacher in the control school mentioned that meal planning was not the focus of this topic. This shows a deficiency in syllabus interpretation since a meal plan is the main product of this subtopic as per the syllabus. Teachers are advised to look at learners' meal plans in the sample assessment strategy.

DISCUSSION

The effect of the PBLWorks model on nutrition knowledge

The baseline findings revealed that over 50% of the meal plans were dominated by cereals, fish, iron-rich organ meats, sweets, and spices. This could be because these food groups are more prevalent as staple foods in communities where learners were coming from [39]. According to Muyonga [40], the inclusion of iron-rich organ meats could be attributed to an awareness of their nutritional value and cultural norms where organ meats are valued parts of the diet. The preference for sweets and the use of spices to enhance meal flavor reflects typical young individuals' taste preferences and cultural cooking practices [41].

Conversely, less than 30% of learners planned for vitamin A-rich vegetables, dark green leafy vegetables, other vegetables, vitamin A-rich fruits, and red palm products. Similar to the study by Aura [42], this underrepresentation may stem from a lack of awareness about the nutritional benefits of these foods and how to incorporate them into meals. Also, according to Beal, Morris [43] young individuals might prefer more palatable foods and find the taste of these vegetables less appealing.

By the end of the intervention, there was a notable shift in the meal-planning behaviors of learners in the intervention school compared to those in the control school. Specifically, the percentage of learners in the intervention school who planned for cereals significantly decreased, while in the control school, this percentage increased. This suggests that the intervention effectively encouraged learners to diversify their food choices and reduce their reliance on cereals. This shift could be attributed to increased awareness of the importance of including a variety of food groups since considering a balanced diet is one of the principles of meal planning [44]. Similarly, the percentage of learners planning for eggs reduced in both the intervention and control schools, mirroring the findings by Rudolph, Kroll [45], but the reduction was significantly more pronounced in the intervention school. This could indicate that the PBLWorks model approach used during the intervention made learners more conscious of diversifying their protein sources beyond eggs. The substantial decrease in egg planning in the intervention group may reflect an improved understanding of the need for dietary variety as well as observation of food variety in meal planning [46]. Overall, the study revealed no significant change in the number of days planned for the consumption of protein-rich foods. However, there was a significant increase in the mean number of days haem-iron-rich foods and vitamin A-rich foods were planned for. The significant increase in planning for haem-iron-rich and vitamin A-rich foods suggests that learners in the intervention group gained a better understanding of the health benefits associated with haem-iron-rich foods and vitamin A-rich foods hence their increased incorporation in meal plans [47]. The lack of a significant change in the planned consumption of protein-rich foods is because these foods were planned to be consumed almost daily at baseline and that didn't change by endline.

These changes in the planned consumption of various food groups led to an overall improvement in the dietary diversity and food consumption scores and NCD protect scores of meal plans of learners in the intervention school. The increased diversity of foods in meal plans reflects a more balanced approach to nutrition, likely due to the educational components of the intervention [48]. By teaching learners about the nutritional benefits of different foods and how to include them in their diets, the intervention successfully broadened their understanding of dietary habits and improved their knowledge of meal-planning. This improved dietary diversity is an important outcome, as it suggests potential long-term health benefits for the learners. Also, the significantly higher in NCD protect scores in the intervention group than the control group by end of the intervention can be directly attributed to the PBLwork model procedure they followed. Learners in the intervention group, gained more foundational understanding of the role of fruits, vegetables, fats and sugars in the diet. This knowledge is crucial for NCD prevention, as it helps learners understand how imbalances, such as excessive intake of unhealthy fats and sugars, can contribute to conditions like obesity, diabetes, and cardiovascular diseases [49] as fruits and vegetables plays a preventive role [50]. So, by understanding these basics, learners are better equipped to plan meals that avoid excessive unhealthy components and include protective nutrients.

Overall, during the projects, learners in the PBLWorks group made meal plans representing diverse cultures in Uganda and received continuous feedback about their meal plans before being permitted to proceed and prepare the meals which a teacher in the control school said would be taught later much as the syllabus flags it as the major product of the intervention subtopic. According to [51], in the intervention group, the iterative process of receiving feedback and refining meal plans ensured that learners continuously improved their understanding and application of nutritional principles as revealed by the results of the meal planning assessments. In this study, assigning learners to complete projects with culturally-based meal plans and preparations, according to the PBLWorks model helped learners gain knowledge of how food varies throughout cultures and the connection between nutrition and health, as required by the curriculum (NCDC, 2019). So, through participating in the PBLWorks model, nutrition knowledge was enhanced as shown by attaining the corresponding learning outcomes in meal planning.

This was not possible in the control school due to sticking to the learners' books and deficiency to identify a meal plan as a major product of this subtopic as per the NFT syllabus (NCDC, 2019).

5. Conclusions

When the PBLWorks model is implemented as a central teaching method, it significantly improves learners' knowledge of healthy meal planning compared to group work discussions as evidenced by a significant increase in the diversity of foods on their meal plans and the frequency of consumption of vitamin A and Haem iron-rich foods.

6 Recommendations

Since the PBLWorks model enhanced nutrition knowledge, NFT teachers should use PBL as the central teaching method. So, much as the current guidance on project-based learning in NFT in Uganda is for learners to do projects after a topic has been taught, such guidance should be reconsidered.

This study was only carried out in Kampala and hence limited in geographical scope, a replication of the study in the whole country is recommended. Even though the findings show that assessment does not significantly contribute to enhancement of nutrition knowledge, further studies on assessment for leaning in PBL are recommended as assessment is central to the learning process.

REFERENCES

1. McCloat A, Caraher M. An international review of second-level food education curriculum policy. Cambridge Journal of Education. 2020; 50(3):303-24.
2. Wahome GO. Secondary school learners' perception of home science subject in Nairobi province. A Research Project Submitted in Partial Fulfillment of the Requirement for the Award of Master of Education Degree in Educational Administration and Planning: University of Nairobi. ; 2005.
3. Rogers MA, Amer H. Food as we knew it: Food processing as an evolutionary discourse. Trends in Food Science & Technology. 2022;128:68-74.
4. Mubita SL. The decline of Home economics in Zambian Basic Schools: The case of Lusaka district. A dissertation submitted to the University of Zambia in partial fulfillment of the requirements for the award of the degree of Master of Education in Education Sociology of the University of Zambia2010.
5. Leepile G. Assessing home economics coursework in senior secondary schools in Botswana. Thesis submitted in partial fulfilment of the requirements for the degree Master of Education Assessment and Quality Assurance Education of University of Pretoria. https://repository.up.ac.za/bitstream/handle/2263/25325/dissertation.pdf?sequence=1&isAllowed=y, editor2009.
6. Hakim M. History of home economics in Uganda. 2017.
7. Scanlon D. Education in Uganda. Department of Health, Education, and Welfare. Office of Education. ; 1964.
8. EACE. East African Certificate of Education. Regulations and syllabus. In: council TEAE, editor. Kampala Uganda 1974.
9. NCDC. Lower secondary curriculum. Nutrition and Food Technology Syllabus Kampala Uganda: NCDC; 2019.
10. NCDC. Integrated production skills (IPS). Food and Nutrition Syllabus. In: NCDC, editor. Kampala Uganda 2010.

11. Mamba NPS, Napoles L, Mwaka NM. Nutrition knowledge, attitudes and practices of primary school children in Tshwane Metropole. African Journal of Primary Health & Family Medicine. 2018;11(1), a1846.
12. Ndahura BN. Nutrition literacy status of adolescent learners in Kampala district, Uganda. Master thesis of the faculty of Health Sciences, Oslo and Akershus University College of Applied Sciences2012.
13. Talagala IA, Arambepola C. Use of food labels by adolescents to make healthier choices on snacks: a cross sectional study from Sri Lanka. BioMed Central Public Health. 2016;16:739.
14. Kyomuhangi P, Tamare A, Atuheire CGK. Nutritional knowledge, attitude and practices of adolescents towards healthy eating in secondary schools in Sheema municipality, Sheema district, Uganda. IAA Journal of Scientific Research 2022;9(1):34-51.
15. Kusemererwa DO. Nutritional awareness among secondary schools students in Maganjo – Wakiso district. A project report submitted to the department of food science and technology in partial fulfillment of the requirement for an award of a degree in bachelor of science in human nutrition: Makerere University library; 2021.
16. Abdulwahab AN. Nutritional Knowledge among High School Male Students in Kuwait. Journal of Community Medicine & Health education journal. 2018;8(5).
17. Oti JA, Amoah AN. Nutritional Knowledge and Food Consumption of Adolescent Students in Junior High Schools in a Rural Community in the Eastern Region of Ghana. American Journal of Food and Nutrition. 2019;7(2):36-42.
18. Okeyo AP, Seekoe E, Villiers Ad, Faber M, Nel JH, Steyn NP. The Food and Nutrition Environment at Secondary Schools in the Eastern Cape, South Africa as Reported by Learners. International Journal of Environmental Research and Public Health. 2020; 5;17(11): 4038. .
19. Badrasawi M, Anabatawi O, Qaissieh M. Nutrition knowledge and dietary practices among secondary school students in HebronPalestine: a cross-sectional study. Palestinian Medical and Pharmaceutical Journal (PMPJ). 2021;6(1): 00-00. https://staff.najah.edu/media/published_research/2020/10/23/Nutrition_knowledge_and_dietary_practices_among_secondary_school_students_in_Hebron-_Palestine_a_cross-sectional_study.pdf.
20. Ateya ESM, Fouad NA, El-Wahid HAA, Younes MM. Knowledge Attitude and Reported Practices toward Optimal Nutrition among Preparatory School Learners. Port Said Scientific Journal of Nursing. 2016;3(2).
21. MOH. DIETARY ASSESSMENT OF SECONDARY SCHOOL LEARNERS IN AND AROUND KAMPALA,UGANDA JUNE 2024 Ministry of Health; 2024.
22. Thomas JW. A review of research on project-based learning. http://wwwbobpearlmanorg/BestPractices/PBL_Researchpdf. 2000.
23. Zhang J, Liang D, Zhao A. Dietary Diversity and the Risk of Fracture in Adults: A Prospective Study. Nutrients. 2020;12(12): 3655.
24. Sari NHY, Muhsinatun SM. The Effectiveness Of Project-based Learning And Problem- Based Learning Models Towards Geography Learning Outcomes In Terms Of Students' Locus Of Control. Geosfera Indonesia. 2018;3(3):16-25.
25. BIE. Gold Standard PBL: Project Based Teaching Practices. 2019;https://my.pblworks.org/system/files/documents/Gold_Standard_PBL_Teaching_v2019.pdf.
26. Vygotsky LS. Mind and society: The development of higher psychological processes: Cambridge, MA: Harvard University Press.; 1978.

27. Price C, Mohammed S, Rabbit B. BetterLesson and PBLWorks professional learning at LUSD: Effects on instructional behaviors and learning outcomes. Prepared for: Lindsay Unified School District Teacher and School Leader Initiative (TSL)2019.
28. Evans CM. Student Outcomes from High-Quality Project-Based Learning: A Case Study for PBLWorks. National Center for the Improvement of Educational Assessment. 2019.
29. Darling-Hammond L, Flook L, Cook-Harvey C, Barron B, Osher D. Implications for educational practice of the science of learning and development. Applied Developmental Science. 2019; 24(2):97–140.
30. Creswell JW. Research design : qualitative, quantitative, and mixed methods approaches. United States of America: SAGE Publications, Inc.; 2014.
31. Creswell JW, Creswell JD. Research design: Qualitative, Quantitative, and Mixed Methods approaches. USA: 6th edition; 2023.
32. Wormack L, Brechtel L, Ubah C, Frazier A, Jackson CG, Nathaniel TL. A student-centered intervention program to educate and retain knowledge in stroke education and healthy habits Preventive medicine reports. 2019;14 (100878).
33. Adeoya AA, Akinwusi AT, Nagatomi R. Effectiveness of nutrition education in enhancing knowledge and attitude of pupils on choice of school mid-day meal in Ibadan, Nigeria. Journal of food science and nutrition. 2023;00:1–9.
34. Beinert C, Overby NC, Vik FN. Project lifelab food and health Innovative teaching for the future: development of student active learning tasks for Home Economics education in the 21st century. Centre for Educational policy Studies journal. 2021;11(4).
35. Nosi C, D'Agostino A, Pratesi CA, Barbarossa C. Evaluating a social marketing campaign on healthy nutrition and lifecycle among primary-school children: A mixed-method research design. Evaluation and program planning. 2021;89(2021):101965.
36. Hutchinson J, Christian MS, Evans CEL, Nykjaer C, Hancock N, Cade JE. Evaluation of the impact of school gardening interventions on children's knowledge of and attitudes towards fruit vegetables. A cluster randomized trial. Appetite. 2015;91:405–14.
37. Fusch PL, Ness LR. Are We There Yet? Data Saturation in Qualitative Research. The Qualitative Report2015.
38. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006;3(2):77-101.
39. Kreitzman M, Toensmeier E, Chan KMA, Smukler S, Ramankutty N. Perennial Staple Crops: Yields, Distribution, and Nutrition in the Global Food System. Front Sustain Food Syst 2020;4:588988.
40. Muyonga J. DIETARY PATTERNS IN UGANDA AND THEIR INFLUENCING FACTORS: A CRITICAL REVIEW. African Journal of Food, Agriculture, Nutrition & Development. 2023;23(2).
41. Drewnowski A, Monsivais P. Taste, cost, convenience, and food choices. Present knowledge in nutrition: Elsevier; 2020. p. 185-200.
42. Aura LA. Consumer Knowledge, Attitudes And Practices on Food fortification in Kenya: JKUAT-CoANRE; 2022.
43. Beal T, Morris SS, Tumilowicz A. Global Patterns of Adolescent Fruit, Vegetable, Carbonated Soft Drink, and Fast-Food Consumption: A Meta-Analysis of Global School-Based Student Health Surveys. Food Nutr Bull. 2019;40(4):444-59.

44. Chen P-J, Antonelli M. Conceptual models of food choice: influential factors related to foods, individual differences, and society. Foods. 2020;9(12):1898.
45. Rudolph M, Kroll F, Muchesa E, Manderson A, Berry M, Richard N. Food insecurity and coping strategies amongst students at University of Witwatersrand. Journal of Food Security. 2018;6(1):20-5.
46. Türkmenoğlu C, Uyar AŞE, Kiraz B. Recommending healthy meal plans by optimising nature-inspired many-objective diet problem. Health Informatics Journal. 2021;27(1).
47. Charlebois E, Pantopoulos K. Nutritional aspects of iron in health and disease. Nutrients. 2023;15(11):2441.
48. Abraham S, Noriega BR, Shin JY. College students eating habits and knowledge of nutritional requirements. Journal of Nutrition and Human Health. 2018;2(1):13-7.
49. Fedacko J, Takahashi T, Singh RB, Pella D, Chibisov S, Hristova K, et al. Globalization of diets and risk of noncommunicable diseases. The role of functional food security in global health: Elsevier; 2019. p. 87-107.
50. Abu-Baker NN, Eyadat AM, Khamaiseh AM. The impact of nutrition education on knowledge, attitude, and practice regarding iron deficiency anemia among female adolescent students in Jordan. Heliyon. 2021;7:e06348. .
51. Brown JM, Savaglio R, Watson G, Kaplansky A, LeSage A, Hughes J, et al. Optimizing child nutrition education with the foodbot factory mobile health app: formative evaluation and analysis. JMIR formative research. 2020;4(4):e15534.