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Evaluation of Problem-Based Learning Experiences Addressed to Health Promotion in the Fourth Grade of Primary School

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Abstract: The global issues of overweight and sedentary lifestyles demand comprehensive responses from health systems, yet health education still needs to be more cohesive and less sporadic. This study focuses on primary school children as a specific target for instilling healthy habits, employing active learning strategies to address healthy diet and physical activity. Through Problem-Based Learning projects, the study engaged fourth-grade primary students in acquiring healthy habits. The study was carried out over four consecutive years at a school with two lines, allowing the employment of an opportunity sample and evaluating intervention and control groups by comparing their corresponding scores. Control groups integrated a total of 54 students, while the intervention group included a total of 159 students. A pre-test and post-test questionnaire were used for data collection. Evaluation differential scores revealed statistically significant higher scores in the intervention groups: 3.62 points in control groups and 6,94 in intervention groups, particularly in attitudinal competences. These strategies not only facilitated the development of crucial skills such as information search, synthesis, representation, analysis, decision-making, teamwork, and intrapersonal awareness but also significantly broadened the knowledge acquired in aspects related to healthy habits. This approach proved effective in helping children comprehend the importance of healthy choices and encouraged integrating such habits into their daily lives.

Keywords: health education; healthy habits; healthy diet; active learning strategies; problem-based learning; instrumental skills; attitudinal competences; primary school

1. Introduction

Children overweight and obesity are global health problems. The trend is growing everywhere. The prevalence of overweight (including obesity) among children and adolescents aged 5–19 has risen dramatically from just 8% in 1990 to 20% in 2022[1,2]. Diet patterns in countries with a traditional healthy diet, such as China or Spain, are progressively farther from the original food, recipes, and cooking methods. Fast food is increasingly available, published, and demanded by children and young people [3]. At the same time, sedentary habits are increasing. Public policies against these problems are insufficient, poorly funded, and even handicapped by food industry pressures [4].

Children's obesity prevention must be embedded into health and education systems[5]. School health education should be a priority because of its universal scope, children's unique learning power, and the opportunity to build healthy habits instead of replacing inappropriate ones [6].

However, health education is usually approached only broadly from the natural sciences area and is focused primarily on theoretical knowledge; more practical content is introduced from

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physical education, traditionally oriented towards accomplishing cardiovascular exercises [7]. Occasionally, educational programs from the health area are applied as extraordinary and extracurricular activities. Results obtained on these approaches are variable. Though usually favourable in the short term, they fail to modify behaviours effectively [8,9].

New teaching methodologies are now being considered to integrate learning objectives addressing content and skills. A good number of authors show and describe the positive impact that this kind of educational proposal has on students, including project-based learning and problem-based learning (PBL). Here, the teacher assumes a role as a mediator and guide of his students, replacing the former teacher-instructor model.

PBL implementation is not limited to using already developed resources in the classroom but focuses on creating new ones. On the contrary, it requires previous work, a careful and individualized dedication to each group, and consideration of individual needs. As far as we know, there are no reported experiences related to PBL applied to health, not only for achieving theoretical curricula content but also for awakening children's consciousness regarding their health. We aimed to evaluate the feasibility and impact of an innovative and active methodology in the teaching and learning processes, addressing the necessary curricular knowledge and awareness related to acquiring healthy habits.

2. Materials and Methods

We conducted an observational study in the fourth grade of primary school (9-year-old children). It was carried out at a semi-private school with two lines (25-27 students each) for four consecutive years. The chosen topic was related to the knowledge about the human body, health, and hygiene, emphasizing the importance of developing healthy habits. A meta-comprehensive project was designed for the first year, redesigned and oriented towards the problem-based learning approach for the next one, and implemented with some variations over the following two years to meet and respond to the characteristics and needs of each group. To verify the effectiveness of this methodology, one of the lines was established as a control group, while the experience was implemented in the other one. In control groups, traditional teacher-centred methods were used.

2.1. Design of Learning Methods

PBL usually starts from the pedagogical model based on the Theory of Multiple Intelligences [10]. It depends on cooperative learning techniques and uses thinking-based learning strategies such as thinking routines, graphic organizers, and mind maps. Figure 1 displays the design of questions generated and understanding goals.

The final objective of both projects was to elaborate a weekly menu according to the needs of the students. Table 1 shows the *performance activities* established to acquire the necessary knowledge. These activities were classified into start-up, follow-up, assessment, and evaluation activities. Graphic organizers were provided to support students in capturing, searching, synthesizing, and representing information. Mind mapping helped them to check, review, and self-assess the content to be learned. Students were also given several rubrics that allowed them to consider and assess all issues related to completing the different graphic organizers, individually and as a group. The rubrics and their achievement standards served as a guide to judge the quality of their work, both for teachers and students. The use of rubrics throughout the entire teaching and learning process allowed the students to progress in achieving the levels.

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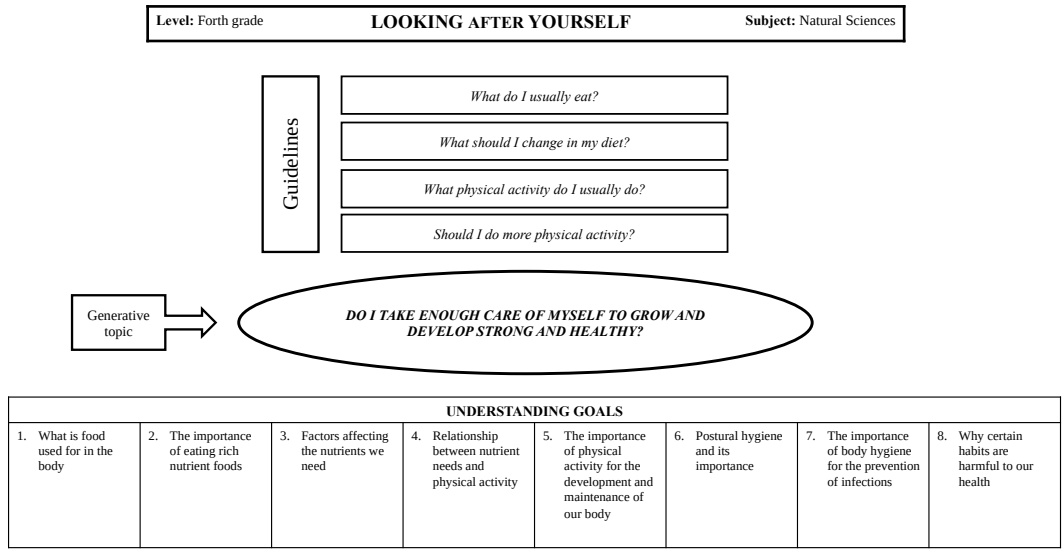

Figure 1. Global problem-based learning design.

Table 1. Looking after yourself: performance activities.

SESSION **TASKS**	**GROUPING** ***COOPERATIVE LEARNING TECHNIQUES***	**INTELLIGENCES IN ACTION**
START-UP ACTIVITIES		
1. Session Physical Activity and Nutrition Log **Evaluation**: Spanish Questionnaire	Individual	Verbal-Linguistic Logical-Abstract Naturalistic Interpersonal Intrapersonal
2nd Session Brainstorming *Why it is important to stay healthy?* Graphic Organizer	Class group	Verbal-Linguistic Intrapersonal Logical-Abstract Interpersonal Intrapersonal
3rd Session Thinking-Routine: *I See-I Think-I Wonder* Food Pyramid Pooling Graphic Organizer	In groups *Round Robin*	Verbal-Linguistic Logical-Abstract Visual-Spatial Interpersonal
FOLLOW-UP ACTIVITIES		
4th -5th Sessions Thinking-Routine: *I See-I Think-I Investigate* Textos & texts *Cornwell Method*	In groups *The Jigsaw*	Verbal-Linguistic Logical-Abstract Visual-Spatial Interpersonal Intrapersonal
6th Session Thinking Routine: *Cause – Effect – Conclusion* *What happens in our body?*	In groups	Verbal-Linguistic Logical-Abstract Visual-Spatial Interpersonal Intrapersonal
7th Session Thinking Routine: *Traffic light* *Which food is healthy?*	In groups *Pens in the Middle*	Logical-Abstract Visual-Spatial Intrapersonal

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Debate Dr Seuss https://www.youtube.com/watch?v=B32u4qrIVZQ	Class Group	Interpersonal Intrapersonal
8th Session Reading: *Golosina y Perezoso* by Willis Graphic Organizer Pooling Thinking Routine: *Part-Part-Whole* *¿What happens if I do not eat…?* Debate	In groups *Shared Reading* Class Group	Verbal-Linguistic Logical-Abstract Interpersonal Intrapersonal
9th Session Reading: http://www.cuentosparaconversar.net/edex_cast.html http://magicfrogtales.com/5-free-short-stories-eat-healthy-be-healthy-and-smile/	Class Group	Verbal-Linguistic Interpersonal Intrapersonal
10th Session Thinking Routine: *The Bridge* Getting older: *What are our teacher's nutritional needs?* Debate	In groups *1,2,4* Class Group	Verbal-Linguistic Logical-Abstract Interpersonal Intrapersonal
11th Session Reading: *¿Quién menea el esqueleto? [Who's shaking the skeleton?]* Graphic Organizer Pooling and debate	In groups *Shared Reading* Class Group	Verbal-Linguistic Logical-Abstract Interpersonal Intrapersonal
12th Session Mind map	Individual	Verbal-Linguistic Logical-Abstract Visual-Spatial Interpersonal Intrapersonal
13-14th Sessions Ideal weekly menu	In groups	Verbal-Linguistic Logical-Abstract Naturalistic Interpersonal
15th Session Written and oral Test **Evaluation**: English Questionnaire	Individual	Verbal-Linguistic Intrapersonal
ASSESSMENT ACTIVITIES		
Personal Diary Graphic Organizer	Individual	Intrapersonal Verbal-Linguistic
Shared Reading	In groups	Verbal-Linguistic Interpersonal
Individual Reading	Individual	Intrapersonal Verbal-Linguistic

2.2. Sample and Data Collection

An opportunity sample was used through four academic years. The teacher who carried out the experience taught both lines for two school years (the second and third of the four years encompassing this study) and only one line for the other two. Children in the second line, the first and fourth years, formed the control group, which integrated 54 students. The exposed group included 159 students.

To evaluate the meta-comprehension project, we used the written test results established to control content acquisition and the improvement achieved when responding to the healthy habits questionnaire as a pre-test and post-test. This questionnaire, provided as Supplementary Table 1, was

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designed "ad hoc." The control group followed the traditional teaching method based on the textbook and performed the same tests and questionnaires.

2.3. Data Analysi

We estimated the mean and 95% confidence intervals for the written test results. The pre-and post-test results were compared using the paired means comparison test. We applied the variance analysis to compare the differences obtained between groups, considering both year and intervention.

2.4. Ethical Issues

We have done an observational study. The teaching methodology was registered in the annual scholar planning and approved by the school management. Only standard evaluation tools were used; to analyse and compare results, every child was identified by a number. No personal data were used.

3. Results

Table 2 summarises the mean pre-and post-tests, stratified by academic year and group. In all cases, the post-test results were significantly higher than the pre-test results, in the control group with a difference of 3.62 points (95% CI 3.23-4.00) and in the exposed groups with an average difference of 6.94 points (95% CI 6.32-7.56) ($p<0.001$). While all groups improved the number of correct answers, this improvement was higher in the intervention groups ($p<0.001$). It highlights that the baseline average scores obtained in the first year (2015-16 academic year) were clearly lower than those obtained in subsequent years. However, the increase was still significantly higher in the exposed lines.

Table 2. Results of pre-test and post-test stratified by group and academic year.

	Pre-test Results Mean (CI 95%)	**Post-test Results** Mean (CI 95%)	**Differences** Mean (CI 95%)
Academic year 2015-16; Control group; N=26	14.96 (13.93 - 16.00)	18.62 (17.45 - 19.78)	3.65 (3.18 - 4.13)
Academic year 2015-16; Exposed group; N=25	15.52 (13.95 - 17.09)	26.32 (25.84 - 26.80)	10.80 (9.38 - 12.22)
Academic year 2016-17; Exposed group; N=54	20.36 (19.61 - 21.11)	26.24 (25.84 - 26.64)	5.88 (5.06 - 6.70)
Academic year 2017-18; Exposed group; N=53	20.38 (19.67 - 21.10)	26.98 (26.56 - 27.40)	6.60 (5.96 - 7.23)
Academic year 2018-19; Control group; N=26	15.12 (13.85 - 16.38)	18.69 (17.32 - 20.06)	3.58 (2.98 - 4.18)
Academic year 2018-19; Exposed group; N=27	18.96 (17.77 - 20.15)	24.89 (23.47 - 26.31)	5.93 (3.91 - 7.94)
Control Group; N=52	15.04 (14.22-15.86)	18.65 (17.75-19.56)	3.62 (3.23-4.00)
Exposed Group; N=159	19.23 (18.65-19.80)	26.05 (25.58-26.52)	6.94 (6.32-7.56)

The acquisition of curricular content was not particularly modified depending on the developed method. Table 3 shows the written test results for each control and exposed group and the ranges they recovered. They did not show differences, except perhaps the wider range in the control groups, where some students reached lower scores.

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Table 3. Average marks in the written test.

Academic Year	Control Group	Exposed Group
2015-16	7.2 (3.3-9.6)	7.5 (4.7-10)
2016-17	-	7.8 (4.4-9.9)
2017-18	-	7.2 (5.0-9.9)
2018-19	7.5 (3.7-10)	7.5 (4.7-10)

Lastly, we analysed the answers to specific questions pre and post-test (Table 4). In the control group, there was a significant improvement for questions 6, 13, 14, and 16 to 28. In the exposed group, considerable progress was made in all the questions, but questions 1, 6, and 11 had a high percentage of correct answers since the pre-test. Comparing the students of both groups' pre-test answers, we realized that the rate of correct answers was higher in the control group only for questions 1 and 3. On the contrary, the percentage of correct answers was higher for 14 out of 28 questions in the exposed group.

4. Discussion

Our results show that by applying new methodologies, the acquisition of curricular content is similar to the groups with the teacher-centred groups. However, the pre-post comparison of the answers to the questionnaire showed a significantly better acquisition of health-related notions in the exposed group. For the questions addressed to conceptual items, the percentage of correct answers improved both in the intervention and control groups. The exposed group improved the questions about attitudes or behaviour intention.

Strength and limitation. We have designed and evaluated a problem-based learning focused on health: "Looking after yourself." The guidelines applied and the final product are fully reproducible and can be adapted to different scholar levels. The mediating action of the teacher in the classroom must be considered. The teacher should have enough knowledge about the needs of the students, as well as a strong motivation regarding health, to offer them a better response and guidance, helping students to achieve more significant progress and commitment, precisely for those students who need it most.

Our study has some limitations. We used an opportunity sample in just one primary school. Despite including multiple intelligences and skills in the project, our intervention did not modify the scholar environment nor included parental involvement. Although we are aware of the importance of these factors having a high impact on health behaviour, it also means that this PBL approach could be applied in other socio-cultural contexts with the same or similar effect. Another limitation is the lack of some evaluation in the long term.

Nevertheless, the long-term effect depends on the successive interventions through scholarly time and on the parental implication. All the studies reviewed show a weakness regarding the outcome measurement. Curricula evaluation is focused on the cognitive area, so the knowledge acquired is easy to measure, but attitudinal achievements are subjectively evaluated. Health behaviour practices are sometimes assessed by self-administering questionnaires without any previous validation. We also measure attitudes through an "ad hoc" questionnaire. To grant the design, implementation, and evaluation of good teaching practices related to healthy diet and physical activity, reaching a consensus about the relevant outcome and the method used to measure it is essential.

School-based programs represent an ideal setting to enhance healthy eating. Nevertheless, elementary school teachers often display low nutritional knowledge, self-efficacy, and skills to deliver nutrition education effectively [11]. There are too few structured scholarly interventions to promote healthy habits. Most of them are based on curricular content, frequently under the guidance of nutrition specialists or other healthcare professionals [12]; however, those that apply cross-curricular strategies or practical learning are more effective [11,13–15]. Other published studies show community interventions improve healthy behaviours. Talks delivered by health professionals add knowledge, but their effects are time-dependent [16,17]. Practical learning by applying cooking

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sessions, school gardens, or even taste [18] has been shown to increase children's motivation related to the intake of fruits and vegetables [19,20]. Our study shows that, although all students improve their results, the increase is more significant in those who work on projects. PBL helps the understanding, organization, and synthesis of information, apart from promoting other interpersonal skills, but it does not replace the time of individual work to consolidate new knowledge [21]. The questions in the questionnaires encompass curricular content and health knowledge as a product of reflection and critical thinking. At this point, intervention groups evidenced significantly greater progress, supporting that PBL helps people learn to think and develop critical, analytical, and reflective thinking. Therefore, the strategies to be carried out must be explicitly instructed and guided, requiring effort and capacity from both students and teachers [21].

In an interesting review, Peralta et al. [11,13] show that resources developed for elementary school teachers to facilitate teaching healthy eating are scarce. Moreover, only some of them embed cross-curricular strategies, experimental learning strategies, or contingent reinforcement activities. The proposal PBL can be considered a cross-curricular strategy because it is developed in a transversal way into several curricula subjects, and it uses experimental learning strategies (e.g., a research project in which children actively look for ingredients of the usual food). PBL methodologies are feasible and can be developed with the usual available resources. This way, better and more homogeneous academic results can be achieved, and at the same time, students can be involved in critical consideration of related health issues. The final product integrates knowledge, beliefs, values, and attitudes, which are, in fact, the starting point for building healthy behaviour. We agree with Murimi et al. [14] regarding the necessity of multicomponent interventions that are age-appropriate and have an adequate duration. Nevertheless, each effort counts, and all teachers could increase the health awareness of their pupils.

5. Conclusions

We can conclude that healthy lifestyle promotion can be integrated into school curricula using problem-based learning. This methodology allows the acquisition of content and helps children understand the importance of healthy choices regarding food and physical activity and incorporate them into their daily lives.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

Author Contributions: BMH conducted the experiment, collected data, and wrote the original draft. PND and ABC participated in conceptualising and designing the methodology; BMH and ABC made data curation and formal analysis. All authors who reviewed and edited it have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflicts of interest.

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