

Comics, Music, Games and Lab Experiments: Nudging Methodology as a Novel Approach in Children's Nutritional Education

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Abstract

Childhood obesity is one of the most challenging public health issues of this century and it has emerged as a pandemic health problem worldwide. Various factors can play a role in causing this condition. Some cannot be changed, such those related to genes and hormones, but others may be within a family's ability to change, such as physical activity and eating habits.

Promoting among children a healthier attitude towards food is crucial for preventing an excessive consumption of fats and sugars, especially because the intake of plant-based foods like vegetables and legumes (V&L) continues to decline. To make V&L more appealing and raise awareness about a balanced diet, educational tools have been implemented as "nudges" with children from primary schools. Nudges are subtle changes in the environment that maintain freedom of choice, but steer people in a particular direction.

The project LO-VEg has designed and tested various tools focused on V&L, such as comics, music, games, and experimental kits, both in formal (i.e., primary schools) and informal (i.e., open-access events) educational environments. V&L were the center of those activities because their adequate intake is essential for a balanced diet and for reducing the childhood obesity risk. The aim of this unconventional nudging approach is to make this topic more appealing for children to promote healthier dietary choices.

Our strategies involved the integration of key information on healthy eating with the creation of different educational approaches, such as a comic book, a song combined with a cartoon, a game focused on the dietary pyramid and/or hands-on experiments to detect the presence of bioactive molecules in V&L.

Preliminary data show that nudging-based strategies can be an effective method for fighting childhood obesity and promoting lifelong healthy eating habits, potentially outperforming more traditional awareness campaigns in schools and in social contexts.

Keywords: Nudges, school, nutritional education, vegetables and legumes, comics, lab experiments

1. Introduction

In recent years, the problem of obesity among children and adolescents has significantly increased [1–3]. The Italian situation is quite worrying because a 2019 study found that almost 10% of children suffer from childhood obesity [4]. A way to evaluate unhealthy eating habits is the analysis of food waste in school canteens, where most children aged between 6 and 11 consume half of their weekly meals. With approximately 700 grams of food wasted per week per person, Italy ranks ninth in the global ranking of food waste, according to data from Green School [5–6]. A study from the Italian Ministry of the Environment has found that roughly one third of the meals served in Italian school canteens is thrown away, with fruit and vegetables among the most discarded foods (58.7%) [7]. A survey by Oricon Hearing (Collective Catering and Nutrition Observatory) also confirmed that in Italy children are especially reluctant to consume vegetables and legumes, because every day 22% of the discarded foods in school meals belongs to side dishes [8].

The cause of this trend is to be found in the eating habits of children, mainly due to the food education imparted by their familiar and social environments. Several studies have shown that a positively structured and non-obesogenic family upbringing strongly contributes in reducing the risk of obesity in children, regardless of genetic predisposition [9].

To foster a behavioral change, a three-stage approach is usually followed: information, imposition of binding rules to prevent options that worsen individual and collective well-being, and use of incentives to promote healthy behaviors. However, these solutions are expensive and not easily accepted or understood by many. Furthermore, what works for adults, may not be effective with children or adolescents (i.e., health claims). Nudges, as proposed by Thaler and Sunstein [10], represent an innovative approach to encourage people to make better choices. Their strategy involves leveraging cognitive biases to induce individuals towards a certain behavior.

2. Nudging Tools

Nudging, also known as the “gentle push”, is a behavioral science technique that guides individual choices without impositions or restrictions. In practice, it involves small changes to the decision-making environment that can influence the behavior in a predictable and positive way. The use of nudging strategies in educational settings – particularly in the context of food education – is proving to be a promising tool for promoting healthy eating habits from an early age. In a school context and in open-access events, the goal of nudging is to encourage a higher consumption of healthy foods, such as fruits, vegetables, and legumes by empowering a “positive” image of them among children.

A broader educational approach where creativity meets science was adopted. Tools like music, comics, games, and experiments specifically focused on this topic, were used to trigger children's curiosity, spark interest, and gently lead them toward healthier choices without any form of coercion. At the same time, these strategies help them to overcome food neophobia – the reluctance to try new foods – making it easier to introduce a more varied and nutritious diet [11–12].

While it is quite easy to capture children's attention, it is not as easy to hold it, and to ensure that the message is kept for a long time. The best way to reinforce the memory is to adopt a synesthetic approach by associating the message with elements that involve other senses (colors, images, tastes, sounds, smells...). It is worthy remembering a Maria Montessori motto «*The child should love everything that he learns, for his mental and emotional growths are linked. Whatever is presented to him must be made beautiful and clear, striking his imagination. Once this love has been kindled, all problems confronting the educationalist will disappear.*»[13].

To reach young learners effectively and durably – in particular at the beginning of the primary school – educators and researchers have explored new interactive, engaging, and entertaining channels. Very effective tools are music and comics, because they easily capture children's attention and imagination. In this context, one specific song and one comic focused on vegetables and legumes have been developed and proposed in several primary schools.

2.1 “Let's Eat a Rainbow”: Music as a Medium for Learning

A joyful and catchy song titled “Let's Eat a Rainbow” has been created accompanied by an animated video. Its goal is to introduce to children the idea that eating a variety of colourful vegetables and legumes is not only healthy, but also exciting, enjoyable, and very cool.

The lyrics of “Let's Eat a Rainbow” reinforce the idea that every colour on our plate has a superpower: i.e., Red foods for heart health, Orange for good vision, Green for strength and energy, Purple/blue for brain power, White/brown for digestion (Fig. 1).

					
YELLOW	ORANGE	PURPLE	RED	GREEN	WHITE
Benefits	Benefits	Benefits	Benefits	Benefits	Benefits
Vitamin C	Beta-carotene	Anthocyanins	Lycopene	Folate	Allicin
Detoxifies, prevents inflammation & improves circulation	Improves immune system function & eye health & reduces risk of heart disease	Improves memory function & reduces free radical damage	Antioxidants that protect cells from damage & help keep our hearts healthy	Helps prevent heart disease & improves digestion	Helps lower cholesterol & blood pressure, reduces cancer risk

Fig. 1. Food colors and their corresponding health benefits

In fact, each coloured fruit, vegetable, or legume is rich in protective compounds and varies in vitamin and mineral content. Therefore to achieve a good range of these precious nutrients is necessary to “eat different colors”. None of them is superior to the other, thereby we need them all. The song promotes positive associations with healthy foods, and creates a playful context where vegetables and legumes are shown as friends, heroes, or even magical elements in child’s everyday world (Fig. 2).

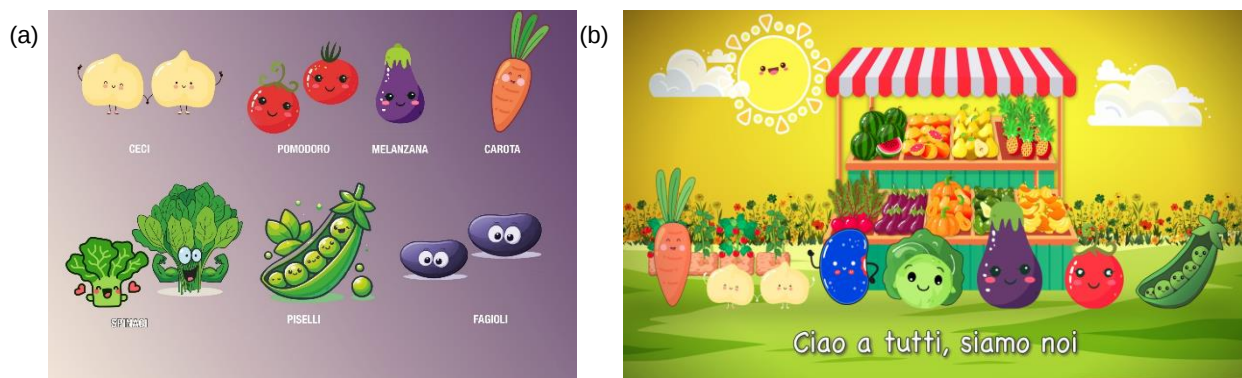


Fig. 2. (a) Cool vegetables acting as players in *Let's Eat a Rainbow* music video; (b) One of the initial screenshots of the music video with subtitles

The combination of music and storytelling offers children a multisensory experience that goes beyond information – it creates connection and emotion. When kids sing together “Let’s Eat a Rainbow,” they’re not just learning, they’re internalizing new habits, having fun, and sharing a moment that can be brought home or to the school canteen.

2.2. Comics: *Super Maria & Paco-Man*

Comics are excellent allies for the little ones and a powerful educational tool, and bring them closer to learning without the pressure of study, because they are considered a pastime. Comics are particularly well suited for conveying complex concepts in an accessible and engaging way, as the integration of text and images facilitates understanding and memory retention, making the information more appealing to children. The choice of a comic for the 6-11 age should be very careful. It must be simple and unequivocal: writing with large characters, clear and beautiful images, fun and engaging texts. David Seelow [14] is a strong supporter of the idea that comics and videogames are not only effective but nowadays necessary pedagogical tools, that can act as a bridge between formal education in schools and non-formal education imparted by many experiences that boys and girls live out of school. In this specific case, the developed educational comic tells the story of *Super-Mari & PacoMan* [15], two siblings with opposed attitudes toward vegetable consumption: Maria, a videogame lover, is reluctant to eat vegetables, and Paco, her younger brother, on the contrary, adores them (Fig.



3).

Fig. 3. (a) Excerpt from the comic *Super-Maria & Paco-Man*; (b) Children from an elementary school in Bologna (IT) reading the comics after a short introductory lesson.

All of a sudden they find themselves trapped inside a videogame, and soon discover that the only way of escape is to play the entire game by overcoming challenges thanks to the "superpowers" gained by eating vegetables and legumes. The playful element of the comic is inspired by pop culture icons and classic videogames (*Super Mario*, *Pac-Man*) and immediately creates a familiar environment for children. In addition, the nutritional message is visually reinforced by the display of an "energy bar" that fills up when the kids eat fruits and vegetables. This multi-colored bar stresses the health values of all vegetables, legumes, and fruits that can be divided in seven groups according to their color. Again a reference to the "Eat a Rainbow" refrain.

2.3 Educational Game: CIBOQUEST – The Food Pyramid Game

A game-based learning methodology can also foster healthy eating habits in children, because serious games have shown to be very effective in different learning contexts [16–19]. Educational games are particularly useful in learning contexts as they create fascinating fictional worlds that can convey important educational messages in a subliminal way, and offer an immersive experience also from an emotional point of view [6, 20].

CIBOQUEST is an innovative educational game developed by the National Council of Research (CNR) with the aim of promoting nutritional education among children through engaging, hands-on learning activities. It is a classical example of science-driven gamification, realized by combining nutritional science, developmental psychology, and educational design. Based on the universally recognized Food Pyramid model, the game transforms a static dietary chart into an interactive experience through a funny and friendly competition. The purpose and educational value of CIBOQUEST is to teach children the principles of a balanced diet through a dynamic game that entails visual memory, attention, and teamwork.

The game is based on a three-step approach (Fig. 4a):

Phase I: Observation – Children, along with parents or caregivers, are grouped into small teams (2-3 per group). The players have just a minute to observe and memorize the distribution of the food items in the pyramid structure displayed on a large poster or on a roll-up banner.

Phase II: Action – The real fun begins! Teams race against the clock (approx. 3 min) to rebuild a 3D version of the food pyramid by collecting food models located in several baskets, and placing each one on the right shelf in a wooden empty pyramid framework (Fig. 4b).

Phase III: Assessment & Reward – Once time is up, the team that has built the most accurate pyramid is proclaimed the winner, and is awarded with a nicely illustrated ten-page recipe booklet containing ideas for healthy and creative meals to try at home.



Fig. 4. (a) Three-step approach adopted in CIBOQUEST game; (b) 3D food pyramid reconstructed.

2.4 Lab Experiments

To catch the interest, while talking about healthy eating habits and learning about the food composition, three simple *hands-on* activities have been also devised (Table 1). These experiments

can be easily performed outside a lab and require readily purchasable, cheap, and non-hazardous materials that can clearly and rapidly show the presence of specific macromolecules, such as starch and proteins, and of enzymes such as catalase.

Human beings obtain energy from three classes of fuel molecules: carbohydrates (i.e., starch), lipids, and proteins. When these materials are “burned”, the hydrogen peroxide that may be produced and can be toxic, is immediately decomposed by the enzyme catalase to protect the cells from oxidative damage.

Table 1. *Hands-on* experiments on food composition and corresponding educational objectives and connections with other curricular topics.

Detection of	Learning objectives	Connections with curricular educational topics
Starch	- Discover foods that contain starch - Nutritional role of starch	Chemistry; Polymers; Carbohydrates; Polysaccharides; Energy storage in plants
Proteins	- Learn what vegetables and legumes contain proteins - Nutritional role of proteins	Chemistry; Food science; Polymers; Amino acids
Catalase enzyme	- Discover foods containing catalase - Learning about its important role as an antioxidant that degrades the hydrogen peroxide produced in cellular processes	Chemical reactions; Enzymes; Oxidative stress; Cell structure

2.4.1 Detection of Starch in Foods

Plants store glucose as starch, a polysaccharide that can be separated into two fractions: amylose (10-20%) and amylopectin (80-90%) that can be broken down into glucose by specific enzymes. Starches are also used in home and industrial preparations as thickening and gelling agents. Amylose in starch is responsible for the formation of a deep blue color in the presence of iodine. The reagent is iodine tincture (also used as antiseptic), a mixture of ethanol and water containing 2–3% iodine and potassium iodide (they form a linear triiodide ion complex that slips inside the amylose coil causing an intense blue-black color, as shown in Fig.5a).

Various samples of food are placed in a multiwell plate and 2–3 drops of iodine solution are added to each well with a pipette (Fig. 5b). In the presence of starch, iodine is trapped into the starch network and the resulting complex turns to blue/black color. If starch is absent, the iodine keeps its original brownish yellow color.

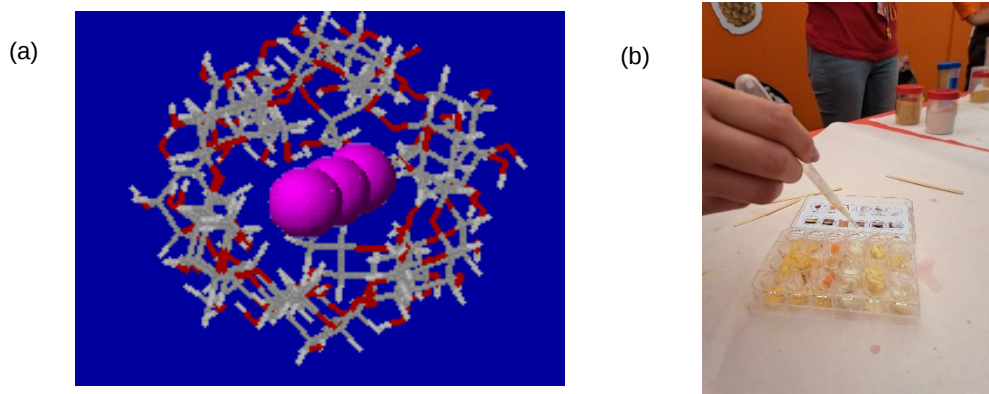


Fig. 5. (a) Starch-iodine complex; (b) Food samples in a multiwell plate: the deep blue color is clearly visible in starch containing foods

2.4.2 Protein Detection

Proteins are polymers of amino acids linked together by peptide bonds. They perform a vast array of functions within organisms: activation of metabolic reactions, DNA replication, response to stimuli,

structure for cells and organisms, and transport of molecules. People usually associate proteins with meat, eggs, and dairy products, but they are contained in substantial amounts also in a lot of vegetables, first the legumes.

A fast and easy way to detect the presence of proteins in foods is the biuret test (Fig. 6): compounds that contain two or more peptide bonds will react with an alkaline solution of copper sulfate (CuSO_4) to form a mauve-colored complex (biuret complex).

The setup of the experiment is quite simple, because it is enough to place a small amount of a crushed food in a container and to add some drops of the alkaline copper sulfate solution to get the reaction.

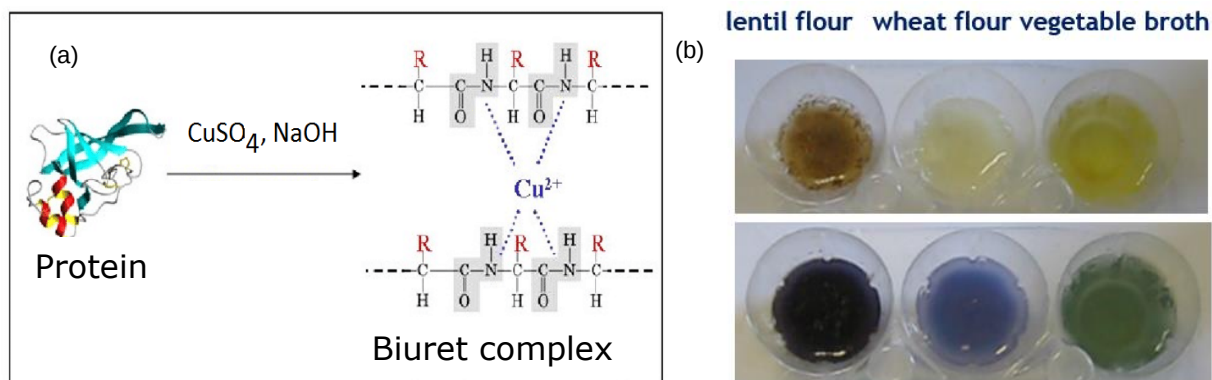


Fig. 6. (a) Formation of the violet complex in the biuret test; (b) food samples analysis (from left): vegetable broth, milk, tomato, chickpeas, reference sampling solution. The violet color of milk and chickpeas shows that they contain proteins.

2.4.3 Detection of the Enzyme Catalase

Enzymes are proteins that act as biological catalysts (molecules that significantly increase the rate of specific reactions). One of the most common enzymes in aerobic organisms is catalase that is also contained in several vegetables. Its role in biological system is to prevent oxidative damage caused by the active oxygen species produced during metabolic transformations. This reaction can be simply triggered by adding drops of a hydrogen peroxide solution on the surface of a fresh-cut vegetable, like a potato, a carrot or an apple. There is an initial rapid evolution of oxygen which lasts for about two minutes, depending on the peroxide concentration. Then oxygen is given off at a steady rate which slowly decreases in the course of an hour (Fig. 7).

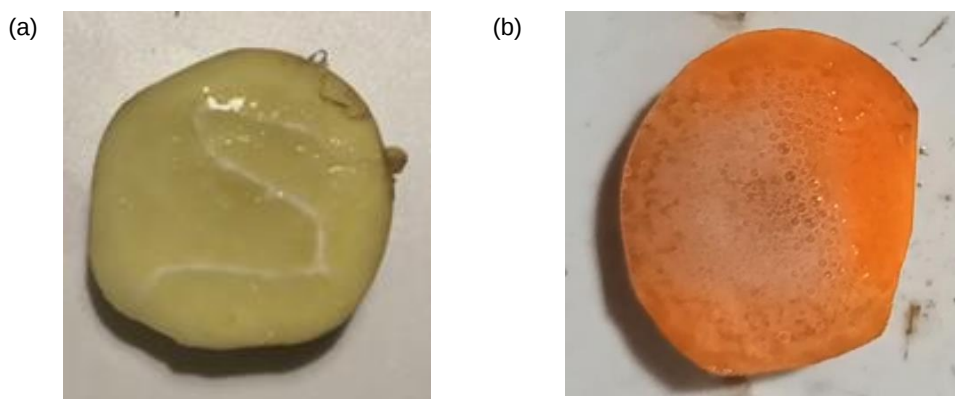


Fig.7. (a) S letter written with hydrogen peroxide on a potato slice by exploiting its reaction with catalase; (b) the same reaction on the surface of a carrot slice.

3. Results and Conclusions

In elementary schools, the song accompanied by the cartoon and the comic strips were used as extracurricular activities (Fig 4b), and as part of nudging-based field experiments in Lombardy region.

These experiments involved approximately 1500 children over a three-week period just before lunch in school canteens. While the comic strips were loved by all children, the song was appreciated mainly by the youngest. The game and the hands-on experiments were used both in classroom and at the Genoa Science Festival, where they were very well received (about 350 children joined the CIBOQUEST game, and 1450 students attended the experiments' sessions) (Fig. 8).

Finally, all tools were presented at Didacta Italia Fair in Florence during a train-the-trainer workshop, and received very positive feedbacks from elementary schools teachers.



Fig. 8. CNR Stand for the experiments at Genoa Science Festival 2024 (above); teachers' training at Didacta Fair 2025 in Florence (below)

In conclusion, the overall results have been very encouraging for the entire team, and confirm that nudging tools are perceived as free, entertaining, and interesting activities, thus making them particularly suitable for use with children and adolescents.

Nudging's major strengths are their simplicity, flexibility, and low cost: the activities can be easily implemented and require minimal resources, making them accessible for many schools. Moreover, they show the potential to create lasting improvements in eating behaviors, thus promoting a more balanced and sustainable food culture [21].

Future research will focus on further refining of nudging techniques and to assess their long-term impact on dietary habits, fostering lasting, health-conscious food choices from an early age.

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