

# Efficacy and acceptability of an Internet platform to improve the learning of nutritional knowledge in children: the ETIOBE mates

R. M. Baños<sup>1,2\*</sup>, A. Cebolla<sup>2,3</sup>, E. Oliver<sup>1</sup>, M. Alcañiz<sup>2,4</sup> and C. Botella<sup>2,3</sup>

<sup>1</sup>Department of Personality, Evaluation and Psychological Treatment, Universidad de Valencia, Spain, <sup>2</sup>CIBER Fisiopatología Obesidad y Nutrición (CB06/03), Instituto Carlos III, Spain, <sup>3</sup>Universitat Jaume I, Castellón, Spain and <sup>4</sup>Instituto de Investigación en Bioingeniería y Tecnología Centrada en el Ser Humano, I3BH, Universidad Politécnica de Valencia, Spain.

\*Correspondence to: R. M. Baños, Facultad de Psicología, Departamento de Personalidad, Evaluación y Tratamientos Psicológicos, Avda. Blasco Ibáñez, 21, 46010, Valencia, Spain. E-mail: banos@uv.es

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## Abstract

Possessing sufficient nutritional knowledge is a necessary component in the prevention and treatment of obesity. A solid understanding of nutrition can help people make appropriate food selections and can also help correct irrational ideas or myths people may believe about food. It is a challenge to provide this information to children in ways that are exciting. Thus, we propose an online video game platform to deliver the information. The objective of this study was to study the efficacy and acceptability of an online game called 'ETIOBE Mates' that was designed to improve children's nutritional knowledge; furthermore, we compare it with the traditional paper-pencil mode of information delivery. A sample of 228 children participated in the study. Participants were divided into two groups: an experimental group (who used ETIOBE Mates) and a control group (who were given a pamphlet). Both groups increased their scores for nutritional knowledge. The interaction between group  $\times$  time was also statistically significant; it indicated that acquisition of nutritional knowledge was superior in the experimental group. The children considered the serious games platform to be a useful medium for improving their nutritional knowledge. Online games can be an effective method of

delivery for preventive and treatment tasks that are otherwise tedious for children.

## Introduction

Prevalence of obesity among children and adolescents has increased dramatically in recent years in North America and Europe [1, 2]. According to the European Association for the Study of Obesity [1], the causes of this epidemic are 2-fold: (i) the increasing availability of 'energy dense' foods and drinks which promote excessive calorie consumption and support a ubiquitous 'snacking' culture and (ii) systematic public and commercial developments which restrict opportunities for physical activity. The current food environment discourages children from developing preferences for low-calorie nutrient-dense fruits and vegetables [3] and exposes them to a range of influences, which increase their risk of becoming overweight. Those influences have been labeled the 'obesogenic environment' [1].

Obesity prevention and intervention programs usually include components designed to promote changes in eating habits and physical activity levels [4, 5]. A knowledge intervention to encourage nutritious and healthy lifestyles is a typical component of existing protocols. Although nutritional education alone is not sufficient to achieve dietary behavior change [6], it is nevertheless a necessary component of broader intervention programs.

Nutrition education intervention programs should be ongoing and multifaceted [7, 8]. Contento [7] reviewed more than 300 nutrition education intervention studies and concluded that the most effective programs are those that are behaviorally focused and based on appropriate theory and prior research. Evidence shows that nutrition education is more likely to be effective when it focuses on behavior and action rather than knowledge alone. Although nutrition knowledge is a necessary but insufficient factor for changes in eating behaviors, it may play a small but pivotal role in the adoption of healthier eating habits [9]. Having a solid understanding of nutrition and healthy lifestyles can help people make appropriate food selections [10] and can also help correct irrational ideas or myths people may believe about food; thus, it is a useful element in protecting people from the 'obesogenic environment' [11].

Nutritional knowledge comprises information on the components of food, medical consequences of a 'bad' diet and basic information about healthy eating habits. Although it is usually easy to teach these principles to adults, it can be more difficult to deliver this information to children in order to prevent and treat childhood obesity. The information and teaching methods can be boring and tedious for children [12], who consequently show a lack of interest in nutritional topics.

Information and communication technologies (ICT) such as the Internet can provide an effective format for presenting educational information on nutrition to children. The Internet is already an integral part of children's environments [13]. Most children have access to the Internet at school or at home [14]. Children use the Internet for entertainment, games, e-mail, chatting and instant messaging; furthermore, most of them believe that it assists them in learning [13].

The Internet allows traditional teaching methods to be combined with more interactive and entertaining methods such as games. 'Serious games' is a term used to refer to digital games designed for educational, persuasive or health purposes. The literature shows that computer games are effective at teaching psychological skills (self-control, attentional training, spatial skills and so on) and promot-

ing educative learning [15]. These games combine both learning and play, making the process of learning new concepts and skills more attractive to children; the games also help to improve the effectiveness and availability of this kind of information [10, 16]. Several studies show that serious games accelerate the learning process and improve motivation levels [16]. The games' benefits as educational tools include that they are (i) highly appealing, (ii) capable of delivering a complex message by consolidating complex information into smaller units that are easier to integrate and (iii) inexpensive to disseminate [10]. Furthermore, (iv) they use a medium appropriate for today's children (the Internet, computer games), (v) they are very adaptable (the targets can be modified according to clinical objectives) and (vi) they reinforce learning and make it more entertaining. Serious games can be very useful for children because children's descriptions of their positive experiences with the Internet most frequently include playing or downloading computer games (17%), watching video clips and songs (13%) and visiting children's entertainment sites (12%) [17].

Several existing approaches use ICT to teach nutritional knowledge [10, 18, 19], including MyPyramid [20] and Squire's Quest! [21]. Both programs are multicomponent interventions implemented in schools as classroom curriculum activities and with teacher participation. However, current evidence on the efficacy of computer-based nutrition education tools is limited. A few studies have compared the efficacy of these tools with traditional oral or paper instruction for children [10, 18]; they did not find that computer games strengthened the impact the intervention had on children's nutritional knowledge. Kreisel [18] compared two school-based interventions: one that included only traditional material and one that used a computer-based educational tool. Results showed no differences between the conditions. More recently, Silk *et al.* [10] compared a website, a serious game (The Fantastic Food Challenge) and a traditional method of teaching nutritional knowledge (pamphlet). Results showed that the website performed the best (for the female group only) in the areas of attention,

understanding and intent to use the information; however, there were no differences in knowledge retention. Studies thus far thus indicate that interactive computer games do not confer greater benefits than traditional modes of nutrition information delivery.

In general, these studies use computer games as part of wider programs and with adults' help. Perhaps the effects of computer games become blurred when other additional components are added. Therefore, the goal of the present study is to compare nutrition-oriented computer games alone with traditional paper-pencil methods.

Our group developed a website called 'ETIOBE Mates' that combines the Internet and computer games to impart nutritional and healthy lifestyle knowledge for the prevention and treatment of obesity in children. The objective of the present study is to analyze the efficacy of this website as a tool for improving the process of teaching nutritional information to children as well as to report results regarding acceptability and playability of the program's games. Age and sex differences will be also analyzed. It is hypothesized that the experimental group (ETIOBE Mates) will improve its nutritional knowledge more than the control group (paper-pencil), and 'ETIOBE Mates' will show good levels of acceptability and playability (medium to high scores).

## Methods

### Participants

We contacted four schools in Valencia, Spain, that were similar in socioeconomic status; a total sample of 228 children (all of them Caucasian) was recruited, aged from 10 to 13 years ( $X = 11.22$   $SD = 0.92$ ), and attending primary school, from fourth to sixth grade. The body mass index SD scores (BMI<sub>z</sub>) average was 0.50 ( $SD = 0.96$ ). Table I shows the data concerning the four different schools, which are participated in the study.

As inclusion criteria, children had to have a computer at home and Internet access. Informed consent for an evaluation was obtained from children and parents. The four schools were randomized into two

conditions: two schools comprised the experimental group (ETIOBE Mates intervention,  $n = 73$  participants; 37% males; age = 11.2) while the other two schools comprised the control group (paper-pencil intervention,  $n = 155$  participants; 43% males; age = 11.2). In order to avoid a contamination effect among children and to control for the possibility that control group participants could have access to the ETIOBE Mates, schools were ascribed to different experimental conditions rather than specific participants. Children from the two schools in the experimental group who did not have Internet access (46 children) at home did not participate in the study. Hence, the control group was larger than the experimental group. We contacted 332 children (151 in the ETIOBE Mates group and 181 in the traditional group). Fifty-five children were excluded because their parents did not sign the informed consent (32 in the ETIOBE Mates group and 26 in the traditional group).

### ETIOBE Mates

ETIOBE Mates was designed to be one component of a broader e-therapy platform, ETIOBE (meaning e-therapy for obesity), which was designed to treat childhood obesity. ETIOBE's goal is to improve treatment adherence and to promote the mechanisms of self-control in children, to ensure maintenance of achievements (reduced body weight) and to prevent relapses by establishing healthy lifestyle habits [22, 23]. The ETIOBE system includes three different applications: a Clinical Support System (CSS; an application used by clinicians to incorporate medical and psychological data into a patient's profile), a Home Support System (HSS; an application which allows children to contact a therapist and access tasks and activities set by the clinician) and a Mobile Support System (MSS; a self-register system, including software that allows children to register information) [24]. ETIOBE Mates was designed as a part of the HSS in the ETIOBE system; however, it can be run independently from the other elements, and it could therefore be included as a component in an obesity prevention program, to teach nutritional knowledge. In the present study,

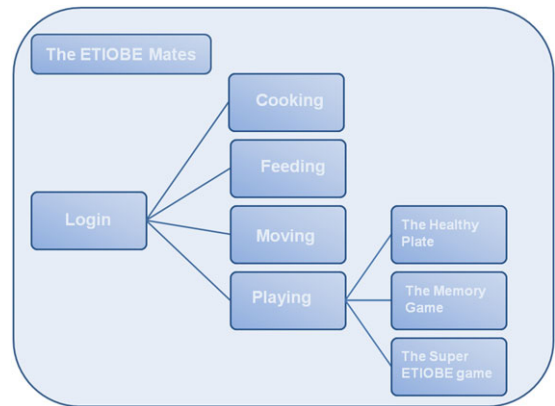
**Table 1.** Description of the participants

Schools	Experimental		Control	
	1	2	3	4
<i>n</i>	30	43	70	85
Gender (boys/girls)	17/13	18/25	40/30	39/46
Age [Mean (Dt)]	11.2 (0.8)	10.9 (0.9)	11.3 (1)	11.1 (0.9)

the objective is to test the efficacy of ETIOBE Mates as an educational tool.

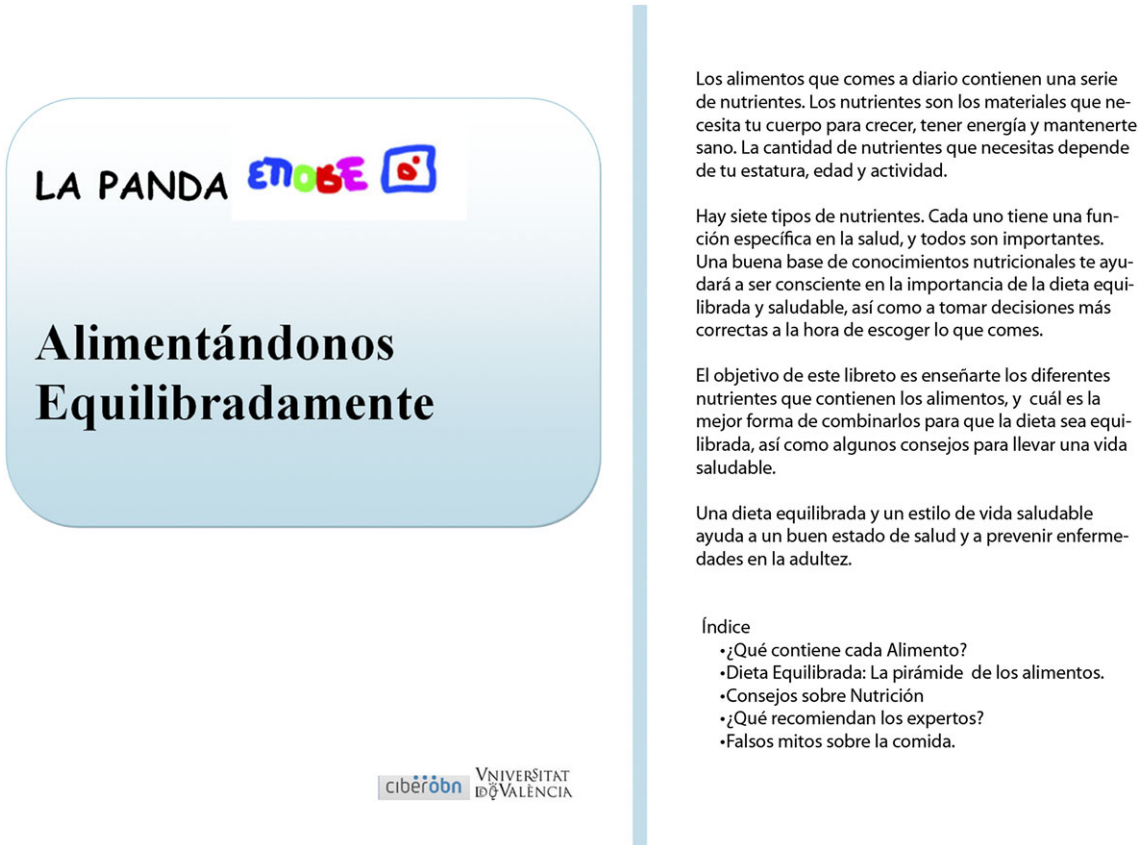
ETIOBE Mates is an educational website including serious games that was designed to teach various aspects of nutritional knowledge and to appeal to children while they learn new material effectively in a fun way. Specifically, information included in ETIOBE Mates games covers the content domains identified by Parmenter and Wardle [25]: nutritional terms (e.g. fiber, proteins), awareness of dietary recommendations (e.g. five pieces of fruit per day), nutrients contained in foods, (e.g. potato has carbohydrate), practical food choices (e.g. breakfast options) and awareness of diet disease associations (e.g. a sedentary lifestyle increases the risk for cardiovascular disease). ETIOBE Mates was designed as a self-applied component of nutritional knowledge teaching, which does not require adult assistance. ETIOBE Mates comprises the following sections (Fig. 1):

- Cooking: The program includes five healthy recipes (with easy instructions for cooking with an adult's help).
- Feeding: The program includes 10 interactive pages containing nutritional knowledge: the food pyramid, the components of food, medical consequences of an unhealthy lifestyle and more.
- Moving: This section incorporates information about physical activity, healthy lifestyles and energy balance knowledge (e.g. a physical activity pyramid, including a classification of activities according to their recommended frequency). It includes four interactive pages.
- Playing: Three serious games are included.
  - The Healthy Plate: This game's objective is to teach the categories of the food pyramid. Users

**Fig. 1.** The ETIOBE Mates platform.

have to associate (draw) different foods with their appropriate categories of the pyramid and select their nutritional properties. After several correct answers, a multiple-choice question appears that must be answered correctly to earn extra points (Fig. 2). An example is: 'Legumes are rich in: (i) proteins, (ii) fat or (iii) cholesterol'.

- The Memory Game: Different cards featuring pictures of food are presented one by one. Users have to find pairs of foods; a correct pair of foods is worth an extra point. Next, users have to answer a multiple-choice question about the characteristics of the specific food (Fig. 3). For example, 'which of these foods are suitable for a snack: (i) hamburger, (ii) chocolate or (iii) apple'. Both games include the same 50 pictures and same 60 multiple-choice questions. The multiple-choice questions have in three levels (easy, medium and difficult). Users were randomly assigned to the



**Fig. 2.** The Pamphlet used in the control condition.

games, and as they played, the level of difficulty increased due to the time allowed to complete the game being decreased.

■ **SuperETIOBE:** This game is a graphic adventure, designed to demonstrate how some daily behaviors can easily be changed to contribute to a healthier lifestyle. It was based on a previous game called ‘Kaiser Permanente’ but adapted to the Mediterranean diet and to the objectives of the ETIOBE treatment. Players have to help a detective (SuperETIOBE) solve cases of children having imbalanced food habits or sedentary lifestyles. Players have to choose the best strategies for improving physical activity or eating habits (Fig. 4). For example, children have to help a girl who is sedentary during her

school break. The gamer has to decide which of several activities would effectively improve her activity levels.

## Measures

- **Internet and game-playing habits:** This is a six-item questionnaire that assesses the playing devices that children have at home (computers, game consoles) and the children’s habits regarding playing computer games and using the Internet.
- **Nutritional Knowledge Questionnaire for children:** This is a 35-item questionnaire that measures children’s nutritional knowledge. It is based



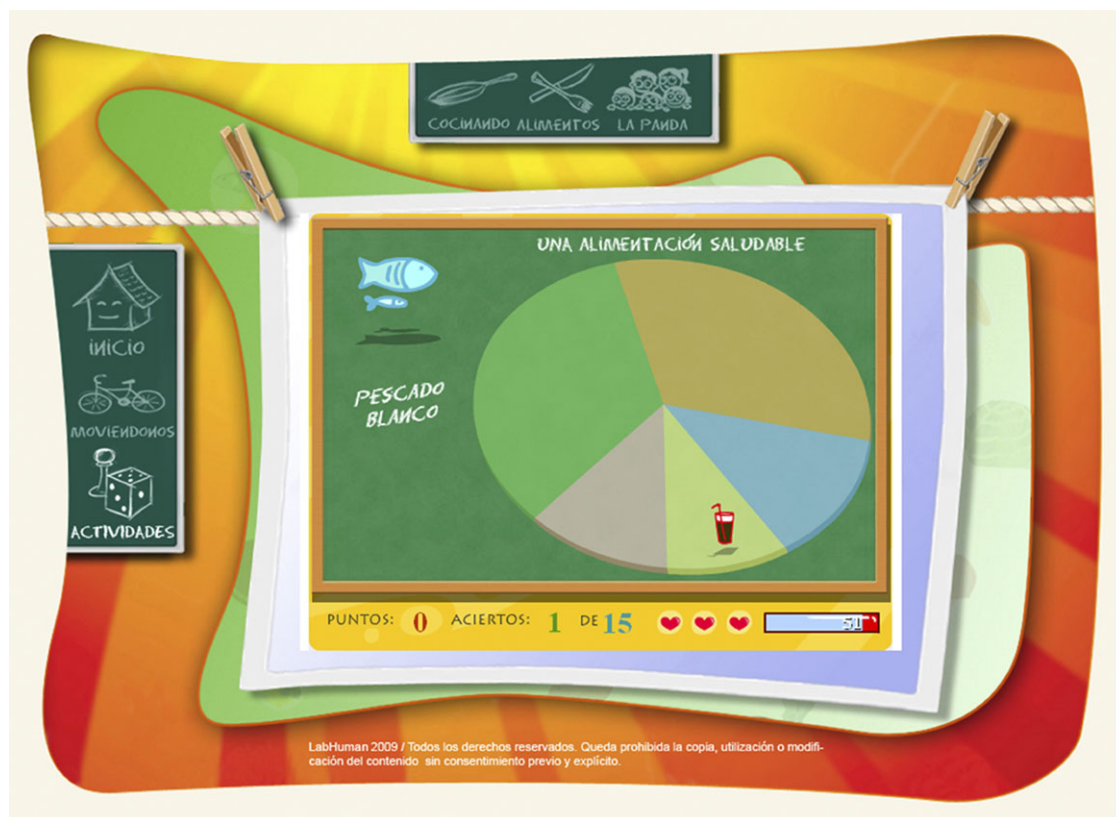


Fig. 3. The Healthy Plate game.

on the 'Nutritional Knowledge Questionnaire' [25] for adults, which shows good psychometric properties: Cronbach's alpha ranged from  $0.70 \pm 0.97$  and test-retest reliability was 0.7 [25]. It was adapted according to the recommendations of Parmenter and Wardle [26] to address the Mediterranean diet, the general knowledge of the children, and to use language that is easy for children to understand. Each item has three possible answers, with one correct answer. An example is: 'what is the function of protein? (i) to maintain and develop our bones, (ii) to contribute energy or (iii) to regulate the body. The final score takes into account any omissions, errors and correct answers, using the following formula:  $[\text{correct answers} - (\text{errors}/2)/35] \times 10$ . The final score ranges from 0 to 10 (with 10 as

the maximum score). Cronbach's alpha for this scale in this sample was 0.68.

• **Acceptability–Playability Questionnaire:** This questionnaire comprises 26 items measuring acceptability and playability of serious games and the ETIOBE Mates website. Acceptability was defined as the users' belief that using new technology would help them improve their performance [27]. This questionnaire was designed specifically for this study. Items were rated on a five-point Likert-type scale ranging from 1 (not at all) to 5 (a lot). The playability subscale comprises 17 items and refers to the degree to which a game is usable and fun to play. The acceptability subscale comprises nine items and assesses the degree to which the player finds the game suitable and useful as a learning tool. Examples are: 'did you like the game?' 'do you

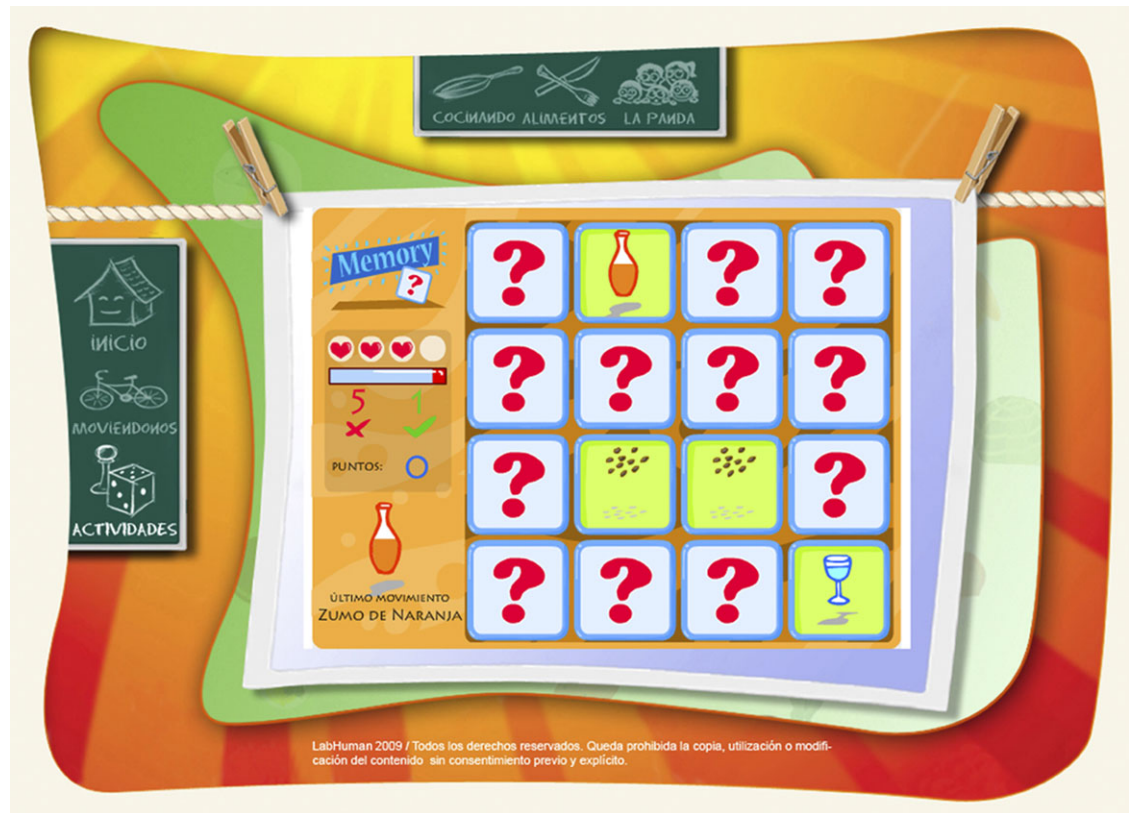


Fig. 4. The Memory game.

think that it is difficult to learn how to play?’. Cronbach’s alpha for this scale in this sample was 0.80 for the whole sample (0.76 for the acceptability scale and 0.80 for the playability scale).

Procedure

Once the parent’s consent was obtained, a team of psychologists visited each school to explain the objective of the research and discuss the tasks. Height and weight measures were taken at school by the researchers’ team, the weight was calculated with a calibrated electronic stadiometer TANITA BC-420 (Holtain, Crymych, Wales). BMIz were calculated adjusting children’s BMI for sex and age. Given that this classification is based on North

American data, the normative data for the Spanish population were used as the correction factor [28].

Participants filled out the ‘Internet and Game-Playing Habits Questionnaire’ and the ‘Nutritional Knowledge Questionnaire’ during class. Then, participants in the control group received a pamphlet with nutritional information adapted for children called ‘Balanced Diet’ (see Fig. 5). The pamphlet provided the same nutritional content as the website, but in a 3-fold paper format. It comprised information about food properties, the food pyramid, experts’ recommendations and common myths about food. The control group was instructed to look at the pamphlet several times per week, as often as they liked, for 2 weeks. At the end of the study, participants in the control group were offered a login and password to use ETIOBE Mates.

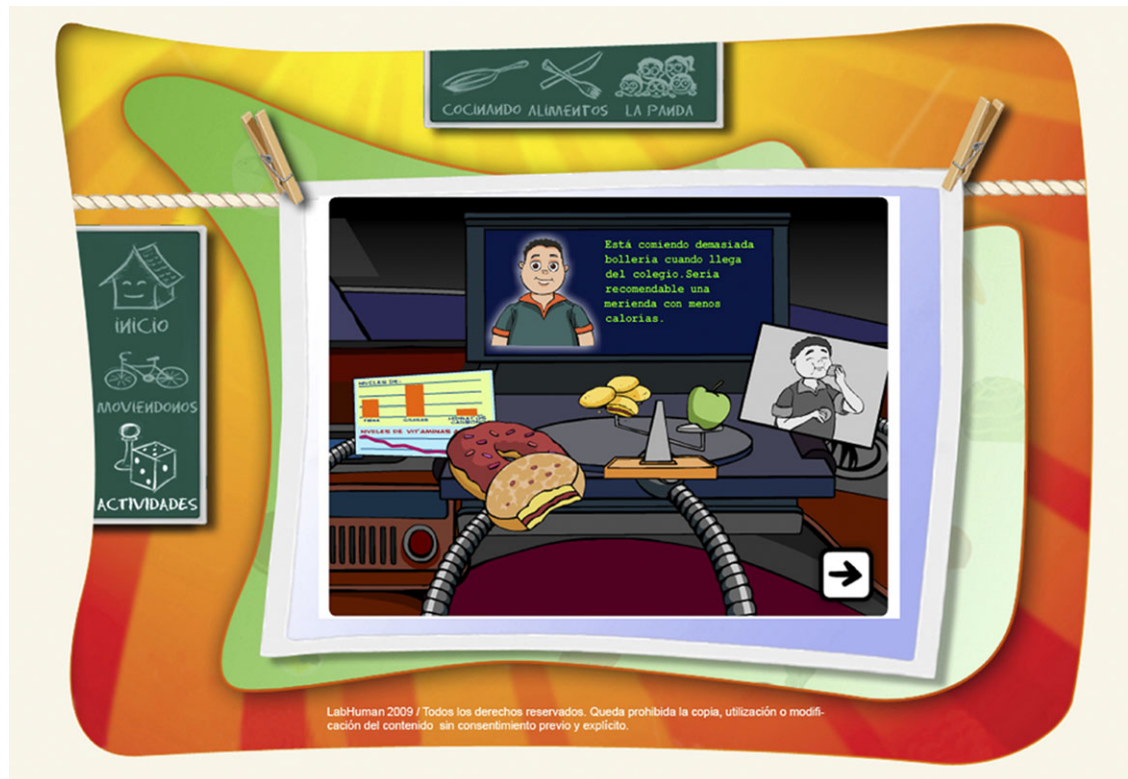


Fig. 5. The SuperETIOBE game.

The experimental group received a password and login to ETIOBE Mates, which included nutritional knowledge and healthy lifestyle information as well as serious games. This group was instructed to navigate to the ETIOBE Mates website and use the programs as much as they wanted to, for 2 weeks. Children played ETIOBE games at home, as schools did not offer time or computers for playing at school.

After 2 weeks, participants again filled out the 'Nutritional Knowledge Questionnaire' during class. Participants in the ETIOBE group were also measured regarding acceptability and playability of the games platform.

### Data analysis

Descriptive analyses were performed to develop a videogame profile of the study population. In or-

der to study the efficacy of the ETIOBE mates to increase nutritional knowledge, a  $2 \times 2$  analysis of variance (ANOVA) (traditional versus ETIOBE Mates; pre versus post) test was applied. To study the acceptability and playability scores, a descriptive analysis with percentages was applied, with a chi-square test, to study the differences between age groups and gender. Finally, a one-way ANOVA test was applied to analyze the differences on the items scores of the acceptability and playability questionnaire. Data were analyzed using SPSS 15.0.

### Results

As previously mentioned, all of the participants had a computer at home. Data regarding frequency at the baseline of use for both groups are shown in Table II; there were no significant differences. Al-



most all participants liked computer games (97.3%) and played frequently. As for video game consoles, 97.3% of the participants had one and most children reported playing every week. Their main Internet use was for playing online games (23.2%), and the majority of children's parents limited their playtime (60%).

### Efficacy of ETIOBE Mates

The descriptive data about Nutritional Knowledge Questionnaire for children are shown in Table III. Results from  $2 \times 2$  ANOVA (traditional versus ETIOBE Mates; pre versus post) indicated a significant effect time factor ( $F(1,226) = 18.319$ ;  $P < 0.001$ ;  $\eta^2 = 0.075$ ). This indicates that both groups increased their scores in the Nutritional Knowledge Questionnaire after the 2-week intervention period. Results did not show a significant effect group factor ( $F(1,226) = 3.731$ ;  $P = 0.06$ ;  $\eta^2 = 0.01$ ). However, the interaction between group  $\times$  time was statistically significant ( $F(1,226) = 4.388$ ;  $P = 0.037$ ;  $\eta^2 = 0.019$ ); the ETIOBE group obtained a greater increase in Nutritional Knowledge Questionnaire scores after the intervention, compared with the traditional group. Analysis was also repeated using age, sex and BMIz as covariables, but results did not show any effect for these variables (age,  $F = 0.001$ ; gender,  $F = 2.262$ ; BMIz,  $F = 0.297$ ).

### Analysis of the Acceptability and Playability

Results on acceptability and playability are shown in Tables IV–VI according to percentages for the total sample and and in Table VII are shown the results for total score according to group ages and gender. In order to analyze differences between age groups (the sample was split into 9- to 11-year-olds and 12- to 13-year-olds) and gender for acceptability and playability, chi-square analyses were applied, but results did not show significant differences for any variable analyzed.

Approximately 50% of the participants liked ETIOBE Mates, similar percentages were found for questions regarding playability: approximately 30% reported ETIOBE Mates to be quite entertaining and about 17% considered it to be very entertaining and fun (Table IV). Regarding suitability to teach nutritional information (Table IV), more than 50% reported that the games were useful to learn nutritional knowledge, and the same that they had learned nutritional information playing the games. The 30% reported changes in their eating habits during the study.

**Table III.** Mean of nutritional knowledge questionnaire for children in both groups

Condition	PRE Mean (SD)	POST Mean (SD)
Traditional	6.25 (1.3)	6.42 (1.5)
The ETIOBE mates	6.46 (1.3)	6.94 (1.4)

**Table II.** Frequency of use of Internet and computer games for experimental and control groups

	Frequency in the use of computer to play games		Frequency in the use of videogames console		Frequency in the use of Internet to play computer games	
	Control <i>n</i> (%)	Experimental <i>n</i> (%)	Control <i>n</i> (%)	Experimental <i>n</i> (%)	Control <i>n</i> (%)	Experimental <i>n</i> (%)
Daily	35 (23.1)	15 (20.5)	15 (10)	9 (13)	40 (27)	12 (16.4)
Three days per week	48 (31.7)	31 (42.4)	41 (27.5)	16 (23.1)	43 (29)	32 (43.8)
Once a week	41 (27.1)	17 (23.2)	41 (27.5)	28 (40.8)	34 (23)	16 (22.2)
2–3 times per month	19 (12.5)	8 (10.9)	35 (23.4)	10 (14.4)	18 (12.1)	8 (10.9)
Less than once per month	8 (5.2)	2 (2.7)	17 (11.4)	6 (8.6)	13 (8.7)	4 (5.4)

**Table IV.** Acceptability and playability percentages of the ETIOBE platform

The ETIOBE mates games	Not at all <i>n</i> (%)	A little <i>n</i> (%)	Sometimes <i>n</i> (%)	A lot <i>n</i> (%)	Very much <i>n</i> (%)
<b>Playability</b>					
Did you like the platform games?	4 (5.4)	27 (36.9)	24 (32.8)	11 (15)	7 (9.5)
Are they entertaining?	5 (6.8)	28 (38.3)	23 (31.5)	12 (16.4)	5 (6.8)
Are they fun?	7 (9.7)	28 (38.3)	22 (30.1)	13 (17.8)	3 (4.1)
Do you think that it is complicated to learn how to play?	60 (82.1)	10 (13.9)	2 (2.7)	1 (1.3)	0
If it is, Have you needed help from an adult?	65 (89)	5 (6.8)	2 (2.7)	1 (1.3)	0
<b>Acceptability</b>					
Do you think that to play these serious games is useful to learn nutritional knowledge?	4 (5.4)	16 (21.8)	16 (21.9)	15 (20.5)	22 (30.1)
Have you gained knowledge about nutrition playing with them?	2 (2.7)	22 (30.1)	17 (23.2)	19 (26)	13 (17.8)
Do you think that can be useful to change food habits?	4 (5.4)	21 (28.7)	19 (26)	20 (27.3)	9 (12.3)
Have you changed your food habits after playing?	24 (32.8)	25 (34.2)	17 (23.2)	6 (8.2)	1 (1.3)

**Table V.** Percentages of difficulty perception of the serious games platform for gender and age groups

	Very difficult <i>n</i> (%)	Quite difficult <i>n</i> (%)	Neutral <i>n</i> (%)	Quite easy <i>n</i> (%)	Very easy <i>n</i> (%)
The level of the game was ...	1 (1.5)	7 (9.5)	14 (19.1)	18 (24.6)	33 (45.2)

**Table VI.** Acceptability percentages of the serious games platform for gender and age groups

Acceptability	Yes <i>n</i> (%)	No <i>n</i> (%)			
If you could do it, would you play more time?	47(64.5)	26(35.4)			
	Daily	More than three times per week	Once a week	Twice a month	Sporadically
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
With which frequency?	2 (2.7)	10 (13.6)	17 (23.2)	10 (13.6)	8 (10.9)

Regarding difficulty (Table V), about 80% of participants reported that they found the games' rules easy to understand. In fact, almost 100% of participants did not need an adult's help to learn how to play. More than 60% (Table VI) would have liked more playtime than the 2 weeks allotted, and most would have liked to play the games once a week. Finally, approximately 40% of participants

found the games very easy, and almost none found it difficult. Any of these percentages showed significant differences between group ages and gender in a chi-square test.

A one-way ANOVA test was used to analyze the total score of each item, according the age groups and gender (Table VII). Results showed significant differences according to gender in experience of

**Table VII.** Scores of the Playability and Acceptability questionnaire for age groups and gender

The ETIOBE mates games	Girls <i>M</i> (SD)	Boys <i>M</i> (SD)	9–11 age <i>M</i> (SD)	12–13 age <i>M</i> (SD)
Playability				
Did you like the Platform games?	2.8 (0.83)	2.9 (0.95)	3 (0.9)	2.3 (0.61)
Are they entertaining?	2.8 (0.84)	2.6 (0.82)	2.9 (0.83)	2.3 (0.71)
Are they fun?	2.8 (0.88)	2.6 (0.86)	2.9 (0.87)	2.3 (0.70)
Do you think that it is complicated to learn how to play?	1.1 (0.33)	1.3 (0.52)	1.2 (0.44)	1.2 (0.38)
If it is. Have you needed help from an adult?	1 (0.1)	1.2 (0.59)	1.1 (0.5)	1 (0.23)
Acceptability				
Do you think that to play these serious games is useful to learn nutritional knowledge?	3.3 (0.91)	4.2 (3)	3.5 (0.8)	4 (1.7)
Have you gained knowledge about nutrition playing with them?	3.1 (0.94)	3.2 (1)	3.3 (0.94)	2.8 (0.99)
Do you think that can be useful to change food habits?	2.5 (0.74)	2.6 (0.93)	2.6 (0.79)	2.2 (0.83)
Have you changed your food habits after playing?	3.3 (0.66)	3.3 (0.75)	3.4 (0.64)	3 (0.76)
The level of the game was ...	3.2 (0.84)	4.5 (02.9)	3.8 (2.3)	3.6 (1.2)

difficulty, boys found the game significantly more easy than girls [ $F(1,72) = 5.39$ ;  $P = 0.024$   $\eta^2 = 0.09$ ] and the youngest group liked more the platform [ $F(1,72) = 0.79$ ;  $P = 0.07$ ;  $\eta^2 = 0.12$ ] found it more entertaining [ $F(1,72) = 5.84$ ;  $P < 0.05$ ;  $\eta^2 = 0.09$ ] and fun [ $F(1,72) = 5.73$ ;  $P < 0.05$ ;  $\eta^2 = 0.10$ ] (Table VII).

## Discussion

Results show that all the participants increased their nutritional understanding. However, the participants in the group that used ETIOBE Mates acquired more knowledge compared with those who accessed the information from the informational pamphlet. However, it must be noted that, even statistically significant, the increase of nutritional information in both groups is small (experimental group increases 4.8% as average and control group increases 1.7 % as average). So, effect size is not large ( $\eta^2 = 0.019$ ). A possible reason that might explain this small increase is that initial nutritional knowledge was moderately high in both groups (6.46 for experimental group and 6.25 for control group, out of 10). The previous knowledge may be due because nutritional information is part of a mandatory subject that children must study in fourth to sixth grades in Spain. Thus, a ceiling effect could moderate the scores, and no too large changes were

observed. Another possible explanation is the duration of the intervention, that is, only 2 weeks, and the lack of teachers support. Maybe longer programs with teachers' help could improve the results. These findings indicate that ETIOBE Mates is a useful tool for imparting nutritional knowledge to children, but it should be explored different ways of applying ETIOBE mates in order to enhance the results.

Results also show good levels of acceptability for the website. Participants reported high usability and acceptability of the website that featured serious games to teach nutritional information. Most of the children reported that ETIOBE Mates was a good tool, and that they learned while they were playing.

Although the games were appealing to the children, a percentage of them did not find it very entertaining. This could be because children are accustomed to playing games designed by established companies, which feature hyperrealistic graphics. The serious games in this study, on the other hand, were designed in simple Flash format to teach educational topics, which might explain their moderate playability ratings. It is challenging to design educational games such as ours that can compete in entertainment value with game consoles used purely for entertainment. As Silk *et al.* [10]

pointed out, games may be more or less effective depending on the audience and context in which they are delivered. For example, different results might be expected from obese children who use ETIOBE Mates as a component of their intervention programs. For them, nutritional knowledge is a necessary component of their treatment; in that context, ETIOBE Mates might be assessed by the users as being more fun and entertaining than learning from a pamphlet. Furthermore, it might be advantageous to advise children during the game's introduction that it is an educative game and that the objective is to learn, not just to play, since nutrition is not a topic that easily attracts children's attention [12]. Further research is needed to determine what factors, such as entertainment value and context, are crucial in designing effective tools.

Regarding other aspects of acceptability and playability, most of the participants reported that the games were easy to learn and that they did not need an adult's help to learn their rules, although boys found it easier than girls. These results are relevant because they indicate that the games would be accessible to the general population.

Furthermore, analysis indicated that there were no differences in efficacy according to group age and sex, but there were differences in playability according to group ages. This signifies that ETIOBE Mates can be recommended for both boys and girls and all group ages. Although data suggest that the younger group liked more the games more than older participants. Some games are designed specifically for girls or boys or for different ages. ETIOBE Mates include simple games that can effectively instruct all children of these ages, and results show that this objective has been fulfilled. Perhaps children older than 14 would find the website too easy, in which case adaptations would be necessary for children aged 14–16 years.

Regarding changing eating habits, participants reported that they changed their habits after playing the games. These data are from self-report measures about subjective perception of habits and might have been influenced by social desirability. Data about consumption frequency and amounts were not obtained before or after our intervention, so it

cannot be proven that eating habits had actually changed. At any rate, results are very encouraging, considering that the children could only access the website for 2 weeks and that the games were not applied as part of a general prevention-treatment protocol. Of course, to achieve more significant changes in food intake, more components might be needed as well as support from other individuals (parents, teachers, etc.). As Contento [8] points out, effective nutrition education is more than information dissemination; it 'needs to address food preferences and sensory-affective factors; person-related factors such as perceptions, beliefs, attitudes, meanings and social norms and environmental factors' (p.176). Nutrition education has at least three essential phases: a motivational phase (to increase awareness and enhance motivation), an action phase (to facilitate the ability to take action) and an environmental phase (where nutrition educators work with policymakers and others to promote environmental supports for action) [8]. ETIOBE Mates is an element in the motivational phase that can be combined with others in a multicomponent prevention program or in an obesity treatment program.

As previously mentioned, several existing ICT programs deliver nutritional education, including MyPyramid for Kids [20], and Squire's Quest! [21]. Each of them has proven to be effective at increasing nutritional knowledge. However, in our study, the serious games were the only activity the children had; ETIOBE Mates was not combined with other school curricula activities, as with the other programs. Another distinguishing characteristic is that ETIOBE Mates was completely self-applied: children played alone at home, without adult assistance [29].

Previous studies that compared different methods for delivering nutritional education have found no differences between traditional and technological tools. Kreisler [18] found that a computer game used in conjunction with traditional teaching tools neither hindered nor strengthened the impact the intervention had on children's nutrition. Kreisler [18] explained the results by noting that the computer game was used in addition to traditional

tools and that not enough time was allocated for using computers. Furthermore, other information obtained through the qualitative data supported the use of computer-based nutrition education tools, since children, especially the youngest, enjoyed working with the computer game and found it to be exciting.

The study by Silk *et al.* [10] is the only one that compared three modalities for delivery of nutritional information: a computer game called The Fantastic Food Challenge, a website and a pamphlet. Their results showed that, after 2 weeks of intervention, interactive computer games did not confer greater benefits than traditional modes of information delivery, but that the website modality was most effective with girls. Differences between participant characteristics might explain the results. In our study, all participants had a home computer and Internet access, whereas in the study by Silk *et al.* [10], only 65% of children had such access. In the study by Silk *et al.* [10], children had to go to the university or other offices in order to get Internet access and play.

The present study has some limitations that should be noted. Firstly, the duration of the intervention was only two weeks; furthermore, follow-up assessment of program sustainability was not examined. Mullen and Shield [30] have suggested that 50 hours of health education is needed to create behavioral change. In order to provide clear recommendations for nutritional serious games, it would be very helpful to have indications about minimum playtime; hence, future studies should clarify the play time necessary to increase nutritional knowledge. Secondly, the Cronbach's alpha of the questionnaire developed for measuring nutritional knowledge was low; this index suggests that the reliability of the questionnaire may affect the results. Thirdly, the sample was imbalanced due to the fact that participants had to have Internet connection at home, and parents had to sign a permission slip. We could not measure the sample of those who decided not participate in the study and thereby it was not possible to tell if there were significant differences in relevant variables with the participants sample. Fourthly, the acceptability

of the traditional condition or pamphlet was not measured; it could be interesting to compare both methods with the same instrument. Fifthly, although the children played at home, the study was utilized in a school context; whether or not these data can also be obtained in a clinical context with obese children should be analyzed. As mentioned above, better results are expected for obese participants because they may be more motivated to learn this kind of information. This limitation is also related to the low levels obtained in playability and acceptability of the platform. This issue could affect the low level of increase in nutritional knowledge.

Future research should assess these critical factors: necessary duration of game use, program effectiveness and the generalizability of such Internet serious games. Limitations aside, data have shown that a short-term Internet-based intervention can successfully improve participants' knowledge of healthy nutritional practices. It is significant that ETIOBE Mates is a low-cost simple program that does not require additional personnel to administer it. As an Internet program, it has advantages in the areas of availability and accessibility. In addition, it also has the advantage of being a serious game, which incorporates fun into the learning environment while enhancing behavior change through attracting and maintaining attention [31]. Internet-based games are a promising medium for encouraging behavior change.

In conclusion, although technology is not the panacea for health education, certain programs can be useful for specific purposes, contexts and target groups [10]. Future research must clarify these variables in order to provide specific prescriptions of what works for whom and in what contexts. Traditional educational tools have a long tradition and body of research. Now, every educational toy includes recommendations about age, objectives and so forth. Similar recommendations are needed about serious games' effectiveness, audience preferences, beliefs, knowledge or level of computer literacy [10].

One of the main objectives of psychological obesity prevention and treatment programs is to change patients' lifestyles, increase motivation and incor-



porate healthy habits that prevent weight increase. The Internet and serious games technology are areas of development that are very useful in stimulating and facilitating behavioral changes. The results of this study confirm the utility and the potentiality of this ICT to stimulate changes in health behavior and promote healthy lifestyles.

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### Conflict of interest statement

None declared.

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