Tasting to preserve: An educational activity to promote children's positive attitudes towards intraspecific diversity conservation.

Patrícia Pessoa [1,*], Sara Aboim [2], Lisa Afonso [3], J. Bernardino Lopes [4] and Xana Sá-Pinto[5]

[1] Research Centre in the Didactics and Technology in the Education of Trainers of University of Aveiro (CIDTFF.UA), 3810 – 193 Aveiro, Portugal; and University of Trás-os-Montes e Alto Douro (UTAD), 5000-801 Vila Real, Portugal; afppatricia@gmail.com

[2] P. Porto: School of Education and Centre for Research and Innovation in Education (inED), 4200-465 Porto, Portugal; saraaboim@ese.ipp.pt

[3] Center for Psychology, Faculty of Psychology and Educational Sciences of the University of Porto, 4200-135 Porto, Portugal; lafonso@fpce.up.pt

[4] University of Trás-os-Montes e Alto Douro (UTAD), 5000-801 Vila Real, Portugal; and Research Centre in the Didactics and Technology in the Education of Trainers of University of Aveiro (CIDTFF.UA), 3810 – 193 Aveiro, Portugal; blopes@utad.pt

[5] Research Centre in the Didactics and Technology in the Education of Trainers of University of Aveiro (CIDTFF.UA), 3810 – 193 Aveiro, Portugal; xanasapinto@gmail.com

*Corresponding author

E-mail: afppatricia@gmail.com (PP)

Abstract

On the edge of causing the sixth big mass extinction event, the development of positive attitudes towards the conservation of intraspecific diversity from early ages is essential to overcome the biodiversity crisis we currently face. However, there is no information available on elementary school students' attitudes toward intraspecific diversity conservation nor is there a framework available to perform such analysis. For this study we designed, implemented, and evaluated an educational activity planned for third graders (8 to 13 years old) to explore the intraspecific diversity of vegetables and to promote healthy eating habits. Additionally, a framework was developed to evaluate students' attitudes towards intraspecific diversity conservation and applied to semi-structured interviews conducted with students before and after engaging in the educational activity. In this paper we present a reliable framework, developed aligned with the ABC model of attitudes, based on literature, and adapted to elementary school students' responses, to evaluate students' attitudes toward intraspecific diversity. Our results show that, before the educational activity, most students choose a non-biodiverse option, justifying this choice with the affective component of attitudes: mostly emotional factors but also aesthetic and social/cultural factors. After the educational activity, we observed a significant increase in the frequency of students that choose the biodiverse option and that justified it with the cognitive component of attitudes: mainly with biology and health knowledge factors, but also with economic and ethical knowledge factors. Our findings support the positive impact of educational activities that explore vegetable varieties on students' attitudes toward intraspecific diversity conservation.

Introduction

Life on earth went through five big mass extinction events - short geological periods during which three quarters of existing species went extinct - and studies on extinction rates show that we are at the edge of causing the sixth one (1). This high extinction rate can be observed across diverse types of ecosystems (2–4) and taxonomic groups (5–7). Biodiversity crisis has multiple causes that are linked and reinforce each other in complex systems that act at both local and global levels (5). Mostly driven by human overpopulation and overconsumption, the major causes of the extinction include habitat reduction, fragmentation and reconversion, climate change, overexploitation, invasive species, diseases, toxification and emerging diseases (5). Researchers have been warning us about the impacts that our actions may have in current and future generations (8). This biodiversity crisis affects ecosystems' equilibrium and may compromise our own survival, negatively impacting the services provided by ecosystems, such as the supply of food and other goods or the regulation of ecosystem functioning, leading to feedback loops that further increase the rate of environmental change (9). This biodiversity emergency is now globally recognized as one of the major socioscientific issues (SSI). In fact, several of the 17 sustainable development goals (SDGs) established by the United Nations (10), such as 'Zero hungry', 'Good health and well-being', 'Responsible consumption and production', 'Climate action', 'Life below water' or 'Life on land' (SDGs 2, 3, 12, 13, 14, and 15 respectively), are strictly related to or affected by the biodiversity crisis.

Overcoming the biodiversity crisis and achieving the 17 SDGs, requires public understanding of biodiversity and the factors that threaten it as well as the development of positive attitudes towards its conservation. According to the International Convention on Biological Diversity (11), biodiversity is "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (p. 16). Studies show that the importance of biodiversity is recognized and understood by both adults and children, but people tend to focus on the importance of the number of species within an ecosystem, with less attention being paid to the ecosystems' diversity or genetic diversity at the intraspecific level (12–14). But, although less publicly recognized, intraspecific diversity is critical in decreasing the probability of extinction by increasing its ability to adapt to environmental changes (15–17). On the contrary, reduced genetic diversity in a population or species decreases its ability to adapt to short (such as a new disease or a severe drought for example) and long term habitat changes (such as climate change for example) increasing the probability of its extinction

(18,19). In addition, intraspecific diversity plays a crucial role in the regulation of ecological processes (20), and is essential to ensure food security, medicine development, to preserve cultural values and diversity and as a source of inspiration (16). In terms of food security, results suggest that intraspecific diversity in agricultural plants may strongly reduce the losses expected in agricultural regions due to global warming (21), contribute to control agricultural pest species affecting crops (22,23) and may enhance the dietary intake of diverse nutrients and influence consumers preferences (24,25). It is thus fundamental that people develop positive attitudes towards conserving intraspecific diversity, and schools represent an ideal setting to develop this awareness (26).

To develop positive attitudes towards intraspecific diversity conservation we should consider that attitudes are a response to a prior stimulus (27). According to Breckler (1984), attitudes are defined as a tripartite model, the ABC model, that includes three components, affect (A), behavior (B) and cognition (C). However, with regard to the factors, there is no consensus on which ones lead individuals to act or not to act towards biodiversity conservation or, even more broadly, towards environmental protection (28–30). Several factors have been shown to influence individuals' actions towards biodiversity conservation, such as demographic, institutional, economic, social and cultural features, knowledge, attitudes, motivation, awareness, values, emotion, responsibility, priorities, childhood experiences, activity choices, personality, perceived behavioral control, behavioral intention, among others (28–30). Despite the lack of consensus, studies have shown that knowledge predicts behavior, although it is considered a necessary but not sufficient condition for decision making (31,32). This is aligned with the elaboration likelihood model (ELM) (33) developed to explain attitude changes. This model predicts that the likelihood and strength of attitudes' changes increases with the degree of time and effort spent by a person on the interpretation of and cognitive building around information important to evaluate the attitudes' object (33). When stronger elaborative processes are promoted and people engage with strong arguments, ELM predicts attitudes' changes that are persistent over time, resistant to counter persuasion and predictive of behavior (33). This highlights a potential role for science education to influence students' attitudes, by allowing students to engage with and elaborate around strong arguments and contributing, among other things, to emotional engagement and knowledge acquisition, which is expected to directly impact the affective and cognitive component of attitude respectively.

Some studies have shown that educational activities can have a positive impact on students' attitudes, such as towards human parasites (34), birds (35), reptiles (36) and conservation of extensive grasslands (37). Furthermore, a survey administered to elementary school students showed that factors such as gender, species knowledge, preferred leisure activities, and family members' involvement in nature protection organizations are a significant predictor of children's attitudes toward insects (38). Concerning biodiversity conservation, a study by Rosalino et al. (39), showed that elementary school students' interests and values related to health and economy may override positive attitudes towards biodiversity conservation. In addition, the same research concluded that students from urban areas are less likely to have a pro-conservation attitude and that they give conservation priority to the species that are most frequently mentioned in online news, particularly mammals and plants. However, to the best of the authors' knowledge, no study examined elementary school students' attitudes towards intraspecific diversity conservation nor is there a framework available to perform such an analysis, despite recent studies showing that younger children have a scientifically acceptable understanding of intraspecific diversity (17,40). Filing this gap can be fundamental to inform the development of educational activities, school curriculum documents, and teacher training.

Food species have observable intraspecific biodiversity attributes (such as taste, shape, and texture) which children can easily explore in hands-on activities (41,42). Healthy eating education is addressed in school curricula in several countries (43–45) and our research team developed an educational program that explored the intraspecific biodiversity of tomato and that fostered children's acceptance of that vegetable (46). Given this, we hypothesize that exploring intraspecific diversity in food plant species can also promote elementary school students' positive attitudes towards its conservation. However, and although some studies analyzed the impact of exploring intraspecific diversity to promote healthy eating (47), no studies analyzed the potential of exploring food to promote positive attitudes towards intraspecific diversity conservation.

With the present study we aim to answer two research questions: 1) what are the elementary school students' attitudes towards intraspecific diversity conservation? 2) how educational activities that explore intraspecific diversity in a food specie affect these attitudes. To answer these questions, in this study, we *i*) developed an analysis framework to identify the factors that influence elementary school students' attitudes toward intraspecific diversity conservation, *ii*) identified the factors that influence elementary school students' attitudes toward intraspecific diversity conservation, and *iii*) studied the impact of an inquiry based learning educational activity designed to increase students' knowledge related to the importance of intraspecific diversity in their attitudes towards intraspecific diversity conservation.

Materials and Methods

To achieve our goals, we implemented a randomized controlled trial. We invited third grade children (8-13-year-old) from one public elementary school from the northern region of Portugal (Girls: 41.6%; Age: M = 8.88; SD = 0.65) to attend the educational activity and answer the short interview described below. Parents of eligible children (62 from 3 classrooms) were asked to allow their children to participate. From the 65 children invited, we collected data from 58 children (33 in the target and 25 in the control group, randomly assigned), due to exclusions caused by withdrawal (n=2), school transfer (n=1) and missing post-test (n=1). The parents from all the students enrolled in this study gave their written informed consent. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all the procedures were approved by the Ethics Committee of the University of Aveiro (Process code 10/2018) and by the school board.

Educational activity

The educational activity was designed for third grade students and was developed to address several learning objectives (view (46) for more detailed information about this activity). Namely, it had as main objectives to promote the valorization of intraspecific diversity of vegetables and healthy eating habits. In accordance with Portuguese elementary school curricula and European recommendations for these school years, this educational activity, addressed learning objectives related to environmental literacy, scientific literacy and health literacy, such as: i) discussions about biodiversity loss and conservation and its impacts on our environment and food security (43), ii) discussions about the importance of a healthy diet and the importance of the correct chewing for proper functioning of the digestive system (43), and iii) engagement in scientific practices, by planning and implementing experiments (43,48,49).

The educational activity comprised three sessions, lasting 60-90 min each (total intervention duration: 240 min), with 10 to 20 children. In the first session, students were introduced to three varieties of tomato (beef, plum and cherry tomato). They were invited to explore the visual differences, to taste slices of each variety and to classify their sweetness and acidity, in a 5-point Likert scale (from not sweet/acid to very sweet/acid, respectively). Based on students' classifications six bar graphs (one per variety for acid and sweet flavors) were constructed and their meaning discussed with the class. In the second session, students analyzed the bar graphs and postulated hypotheses explaining: a) why different varieties of tomato were classified as having different levels of sweetness and acidity; and b) why different individuals classified differently the sweetness and acidity of the same variety of tomato. In groups of 3 to 5, students were invited to plan an experiment to test their chosen hypothesis. During this session, the researchers supported each group in the identification of problems in their experimental design and promoted discussion to find solutions to overcome these. In the third session, each group implemented their experimental plan, collected data, analyzed their results and discussed how these supported or not the initial hypothesis. After this was done in each group, a discussion was held with the whole class in which other vegetables species with diversity were presented, such as *Brassica oleracea* (kales, cabbage, broccoli), *Malus domestica* (apples), *Daucus carota* (carrots). The students' preferences for the different varieties and the consequences of the absence of the different varieties on the cuisine and on whether the students could eat that vegetable were discussed.

While planning and implementing this activity we took into consideration the ELM model of attitudes' change (33). These elements were aimed to increase the students' elaborative processes and the outcomes of these by: *i)* increasing students' motivation (by making the information personally relevant and needed by using vegetables that have several varieties familiar to students, that are often used in Portuguese cuisine, which are easy to find in supermarkets and which students were invited to taste and classify according to their own perceptions), *ii)* increasing their ability to process the information (by creating diverse opportunities to experience - in the first and third session - and discuss about the intraspecific diversity and its value- in the three sessions); and by *iii)* providing them diverse and strong arguments to value intraspecific diversity (by addressing individual emotional preferences, aesthetic and social/cultural values, and biology/health, economic, and ethical knowledge). Namely, during the activity, individual emotional preferences were explored by asking students for their own preferences regarding the diversity of various vegetables. Aesthetic values were explored through the colors of the presented vegetables. Social/cultural values were explored through the importance of intraspecific diversity for Portuguese gastronomy, but also for the traditional gastronomy of other countries accounting for the students' families. Biology and health knowledge covered topics such as: 1) different varieties of a vegetal species have different properties (41,42) - *i*) different varieties have distinct tastes; *ii*) different varieties may have distinct features that make them more suitable for distinct dishes; *iii*) different varieties have different nutritional properties and make our diet more diverse; 2) different varieties may grow and produce differently in distinct environments (42); 3) the food's degree of ripeness alters its flavor (50); 4) different people have distinct abilities to taste some flavors and have distinct preferences (51); 5) it is healthy to eat distinct varieties of a vegetable and/or it is not healthy to always eat the same variety of a vegetable (52); 6) our tastes change over time, so we should try different varieties of vegetables (53); 7) the way we chew food influences the way we taste it (54); 8) the fact that an individual is sick can change the way they taste food (55). Economic knowledge was explored by reflecting on the impact of variety availability on the ability/need to buy and sell vegetables. And the ethical knowledge was explored through different people's preferences for different varieties and their right to assess these.

The interview and its implementation with students

All students were interviewed twice. The students in the target group were interviewed before and after the educational activity. The students in the control group were interviewed in the same period as the students of the target group but only performed the educational activity after the post-test. A semi-structured interview (56) was conducted by one researcher (XSP) who asked students individually to i) pretend to be farmers and select seeds to sow in their imaginary farm from 7 options of bean seed bags each containing a single variety and a biodiverse bag containing seeds from the seven varieties (see Fig 1) and ii) justify their choice. The responses were audio recorded and transcribed and anonymized.

Fig 1. Example of the bean varieties placed in the seven bag options.

Design and application of the analysis framework

To assess the students' attitudes towards intraspecific diversity and the factors that lead those, we developed and applied a framework to perform a content analysis of the answers to the interview. To develop the analysis framework we followed the ABC model of attitudes developed by Breckler (1984), that defined attitudes in three components, affect (A), behavior (B) and cognition (C). According to this model, the affective component (A) is defined as being an emotional response, an instinctive reaction, or sympathetic nerve activity, which in turn can be measured by monitoring physiological responses, such as heart rate, or by an individual's verbal report. The behavioral component (B) is defined by overt actions, behavioral intentions, and verbal statements regarding the behavior. The cognitive component (C) includes beliefs, knowledge structures, perceptual responses, and thoughts. To assess each of these components we divided the students' answers into two segments, choice, and justification (see Fig 2). In the choice segment we assess the student's behavioral intention through the verbalization of which bag of seeds they would buy to sow on their farm. In the justification segment we assess the affective and cognitive components by analyzing the factors stated by the students that influenced them to make a certain bag choice. To assess the factors that lead to the affective and cognitive components of elementary school students' attitudes we created categories based on previous studies on the values, meanings, and representations of biodiversity (57,58), on the factors that lead individuals to act or not act pro-environmentally (29,30), and on the floating reading of the students' answers (see Table 1).

Fig 2. Schematic of the links established between the ABC model of attitude and the structure of students' answers to the interview.

All students' justifications were subjected to a content analysis (56) to evaluate the presence or absence of the categories of analysis. Since attitudes are the result of the interaction of three components, each student answer can be categorized with more than one category. To ensure the reliability of the framework, two researchers (PP and SA) rated 20% of the interview answers. Interrater reliability was estimated as the percentage of the initial agreement between raters (59). Since interrater reliability was > 87%, the reliability of this procedure was considered acceptable (60). The coding of all students' answers was performed by one trained researcher (PP). The answers from the post-test from the students in the control group were used to check for the impact of students' double exposure to the test and to evaluate the internal process validity (61). The pre- and post-tests of the control group did not significantly differ ($p > 0.05$ for all the analysis, see S1 Table for detailed results), thus confirming the internal validity of the process (61).

Statistical analysis

To test for significant differences between pre- and post-tests results for each of the categories of analysis in control and target groups we performed McNemar tests. To study possible associations between affective and cognitive components with the students' behavioral intention in pre- and post-tests we used Chi-square tests. All statistical analyses were performed with SPSS v26.

Results

Framework of analysis

Our final framework of analysis is organized according to the three components of the ABC model of attitudes (27). The affective component was subdivided into three categories (emotional, aesthetic, and social/cultural), the behavioral component was defined by the behavioral intention verbally indicated by the students when choosing the seed bag, and the cognitive component was subdivided into three categories of knowledge (biology and health knowledge, economic knowledge, and ethical knowledge). A description of the categories and examples of students' answers assigned to each category can be found in Table 1. The 'biology and health knowledge' category was defined by the learning goals addressed in the educational activity, and as such, this category may change in other implementation contexts. The learning objectives addressed in our educational activity and the full description of the category 'biology and health knowledge' applied in this study can be found in S3 Table.

Table 1. Framework of analysis applied to assess students' attitudes towards intraspecific diversity.

ABC model component	Factors	Description	Examples
Affective	Emotional	The student justifies his/her choice by referring to personal and individual reasons, preferences, experiences, or habits.	"... because then I could taste them all (...) because I really like beans..." (student 5B, pre-test); "... because since I was a little girl when I ate feijoada [traditional Portuguese dish] I liked it very much..." (student 4A, pre-test); "... because it has all the beans I like and some for me to try (...) because this way we know what is good for us and what is not..." (student 12C, post-test);
	Aesthetic	The student justifies his/her choice by referring to preference for aesthetic characteristics, such as color, shape, smell or because it is more beautiful.	"... because it is my favorite color, it is black, it is very dark..." (student 22C, pre-test); "... I think the color is funny..." (student 18B, pre-test); "... it's more beautiful all varied..." (student 7C, post-test);

	Social/Cultural	The student justifies his/her choice by referring to the importance of the variety(ies) for his/her relatives or people close to him/her, or for the traditions and customs of the community in which he/she is involved.	"... because all my family likes black beans, except me..." (student 10A, pre-test); "... imagine I have a guest and I only have black beans and the guest doesn't like black beans, so if I have one of each my guest can eat the others, which he/she likes..." (student 6A, post-test);
Behavioral	Behavioral intention	The student verbally states the bag of seeds he/she would like to sow on his/her farm.	"this [student points to the biodiverse bag] ... because it has more variety..." (student 13B, pre-test), "this one [student points to a bag with only one variety] ... because I really like black beans ..." (student 6A, pre-test);
Cognitive	Biology and health knowledge	The student justifies his/her choice by referring to biology and health topics addressed in the educational activity[1].	"... because if we always eat the same thing we don't know what the others taste like..." (student 8B, pre-test); "... because when we want a meal we want it with one type of bean, when we want another meal we want it with another type of bean..." (student 12B, pre-test); "... because there are several types of beans and we can't always eat the same thing in excess, it's bad for us, we should always eat a lot of variety because of the different tastes, (...) there could be people who would like some and others who would like others..." (student 7C, post-test);
	Economic knowledge	The student justifies his/her choice by referring to economic issues related to the opportunity of saving or earning money.	"... because if we didn't have them, we would buy them once and have half a bag left over, then another time and we would keep buying them and then we wouldn't spend all [the beans] and this way we save (...) if we buy the bag that has the variety this way we save..." (student 12C, post-test); "... because then I can sell several varieties and people are not always eating the same thing..." (student 11A, post-test);

	Ethical knowledge	The student justifies his/her choice by referring to the importance of variety for all living beings. He/she recognizes the importance of sowing different varieties to suit different people and animals' preferences, referring to people in general who are not close to him/her or in his/her community.	"... because, also people, we are not all the same, because we have variety, there are Chinese people, Japanese people, I think variety is good for everyone..." (student 2A, pre-test); "... because (...) the beans are all varied and so people can choose..." (student 13C, pos-test).

[1] All the biology and health topics explored in the educational activity can be found in S3 Table, as well as examples of the student responses mentioning each of these.

Students' attitudes towards intraspecific diversity conservation

In the pre-test, when we asked students to verbally indicate their behavioral intention, or in other words, which bag of seeds they would choose to sow on their farm, 9.09% of the students in the target group (TG) and 24% of the students in the control group (CG) chose the biodiverse bag. The analysis of the students' justifications in both groups revealed that this behavioral intention - the choice of the biodiverse bag - was followed by justifications that mentioned the 'emotional' (CG= 16%), 'biology and health knowledge' (TG= 9.09%; CG= 16%), and 'ethical knowledge' (CG= 8%) factors.

The students who expressed a choice of a bag with only one variety, presented justifications referring to the affective component, predominantly mentioning the 'emotional' factor (TG= 81.82%; CG= 68%), and to a lesser extent the 'aesthetic' (TG= 27.27%; CG= 4%) and the 'social/cultural' (TG= 6.06%; CG= 8%) factors.

Educational activity's impact on students' attitudes towards intraspecific diversity conservation

When comparing the interview results of the students in the target group, a significant difference in behavioral intention between the pre- and post-test was observed, specifically there was a significant increase in choosing the biodiverse bag (p= .008), with 33.33% of students making this choice in the post-test. No significant differences were observed in the control group (see S1 Table for detailed results). The analysis of the justifications of the students in the target group revealed a significant increase in the mention of the 'biology and health knowledge' factor (p= .008) and a significant decrease in the mention of the 'aesthetic' factor (p= .021) between the pre- and post-test (see Fig 3). The choice of the biodiverse bag in the pos-test was followed by justifications that presented mostly justifications referring to the cognitive component of attitude. More specifically, students predominantly mentioned the factor ‘biology and health knowledge’ (33.33%), but also, to a lesser extent, the factors ‘ethical knowledge’ (9.09%) and ‘economic knowledge’ (6.06%). Although less frequently, the factors of the affective component were also mentioned, namely, ‘emotional’ (9.09%), ‘aesthetic’ (3.03%), and ‘social/cultural’ (3.03%).

Among the students in the target group who mentioned the 'biology and health knowledge' factor in the post-test, they specifically mentioned the following topics covered: *i*) different varieties have different properties, such as taste, nutritional properties, or characteristics that make them more suitable for certain dishes (seven students), *ii*) it is healthy to eat distinct varieties of a vegetable and/or it is not healthy to always eat the same variety of a vegetable (six students), and *iii*) different people have distinct tastes and preferences (three students).

The students in the target group who expressed the behavioral intention of choosing a bag with only one variety of beans in the post-test, all mentioned in their justifications factors related to the affective component of attitudes, namely the 'emotional' (54.55%) and the 'social/cultural' (12.12%) factor.

Chi-square tests showed a significant association of the affective and cognitive factors with the behavioral intention (the bag choice) mentioned by the students of the target group both in the pre and post-tests ($p < 0.01$ for both pre and post-test, see S2 Table for detailed results). In other words, our results showed that the choice of a bag with only one variety tends to be associated with the affective component and the choice of the biodiverse bag tends to be associated with the cognitive component.

Fig 3. Frequencies of students’ answers assigned to each factor in pre- and post-test according to bag choice. The light green bars indicate the students of the target group who chose the biodiverse bag in the pre-test (BiodivPre). Dark green bars indicate the students of the target group who chose the biodiverse bag in the post-test (BiodivPost). Light orange bars indicate the students of the target group who chose the bags with one variety in the pre-test (OneDivPre). Dark orange bars indicate the students of the target group who chose the bags with one variety in the post-test (OneDivPost).

When we focus on the change or non-change in behavioral intention from pre- to post-test of the students in the target group, we found that the students who kept the choice of bags with only one variety (OneDivPre-OneDivPost), having in the pre-test just mentioned the three factors of the affective component, in the post-test showed a decrease in the reference to the 'aesthetic' factor (from seven students to zero students) and an increase in the reference to the 'social/cultural' factor (from one student to 4 students). The students who kept the choice of the biodiverse bag (BiodivPre-BiodivPost), having mentioned in the pre-test only the 'knowledge approached' factor of the cognitive component, in the post-test they also mentioned the 'ethical knowledge', 'emotional' and 'aesthetic' factors (one student in each factor). The students who changed their choice from a bag with only one variety on the pre-test to the biodiverse bag on the post-test (OneDivPre-BiodivPost), mentioned in the pre-test all the factors of the affective component, and in the post-test decreased the reference to the 'emotional' and 'aesthetic' factors of the affective component, and increased the reference to all the factors of the cognitive component. Namely, the 'emotional' factor from eight students was referred in the post-test only by two students, the 'aesthetic' factor changed from two students to none, the 'biology and health knowledge' factor from zero students changed to eight students, the 'economic knowledge' factor from none to two students, and the 'ethical knowledge' factor from none changed to two students. None of the students changed their choice from a biodiverse bag to a bag with only one variety. These differences between the factors mentioned according to whether or not the behavioral intention changes can be seen in Fig 4.

Fig 4. Difference between the absolute frequencies of students' answers assigned to each factor in the pre- and post-test according to change or non-change in behavioral intention. Yellow bars indicate the students who chose a bag with only one variety in the pre- and post-test (OneDivPre-OneDivPost). Blue bars indicate the students who chose the biodiverse bag in the pre- and post-test (BiodivPre-BiodivPost). Green bars indicate the students who chose a bag with only one variety in the pre-test and the biodiverse bag in the post-test (OneDivPre-BiodivPost).

Discussion

With the present study we *i)* developed a valid and reliable framework to evaluate students' attitudes towards intraspecific diversity that is aligned with the literature in the field and adapted to the elementary school students' answers; *ii)* show that, before educational activities, most of the students would choose the non-biodiverse bag, providing arguments mostly related with emotional factors, but also with aesthetic and social/cultural factors to support that choice; and *iii)* support the positive impact of educational activities that explore intraspecific biodiversity of vegetable food species in students' attitudes towards intraspecific diversity.

To the best of the authors' knowledge, this was the first attempt to develop an analysis framework to analyze people's attitudes towards intraspecific diversity conservation. Since this analysis framework was tested in such a specific implementation context and having categories of analysis dependent on the learning objectives addressed in the educational activity, namely the knowledge factors of the cognitive component, this framework has an adaptive character and will benefit from its implementation in different contexts in the future. Implementation in different contexts may give rise to new categories of analysis and even further refinement of existing categories. This framework may be useful to further explore how students' socio-cultural backgrounds influence their attitudes towards intraspecific biodiversity. It will also be important to further evaluate the impact of educational approaches in students' attitudes towards intraspecific biodiversity and to develop more effective educational approaches to enhance public support for biodiversity conservation measures. This is particularly important since intraspecific diversity is essential to ensure food security (16), namely to cope with agricultural losses resulting from global warming, to control pests, and to increase the availability and possibility of intake of various nutrients (21–25).

Regarding students' attitudes towards intraspecific diversity conservation, our results showed that when elementary school students are asked about their behavioral intention, there are few who choose the most biodiverse option. With all the participants in this study being students from a school located in an urban area of Portugal, these results are consistent with the results described by Rosalino et al. (39), which showed that Portuguese students from urban areas are less likely to have a pro-conservation attitude towards biodiversity than students from Brazil or from rural areas. According to our results, the affective and cognitive components of attitudes seem to have different associations with students' behavioral intentions. In fact, the students who chose a bag with only one variety of seeds in the pre-test, referred very often to factors from the affective component, more specifically mostly emotional factors. According to Miralles et al. (62), our emotional connection towards other species has an impact on our attitudes towards them, and this decreases with evolutionary divergence time. But our results further show that a positive attitude towards the conservation of intraspecific diversity is associated with the cognitive component of attitudes. The students who had the behavioral intention of choosing a biodiverse bag in the pre-test, mostly mentioned biology and health knowledge factors, such as different varieties having different properties and the fact that a varied diet is a healthy habit. Rosalino et al. (39), shows that the interests and values related to the students' own health override attitudes towards biodiversity conservation. But in the case of our activity, we associated biodiversity conservation with health knowledge arguments what may have influenced and enhanced the students' choices and positive attitudes towards biodiversity conservation. The use of food species to explore intraspecific diversity may have further facilitated this articulation. Given this, in future studies, it would be interesting to explore whether this type of approach can also have an impact on conservation attitudes towards particular species. A possible example could be the conservation of snakes and other reptiles that usually face strong human persecution (63), but which venom is used as a source of several medicines (64). We should however be careful as the traditional use of some species (including snakes) for ethnomedicine was also shown to be detrimental for these species' conservation (65).

Although less frequently, some students also mentioned emotional factors when choosing the biodiverse bag in the pre-test. These results show that students at this grade level can already have a personal preference for intraspecific diversity, and also, that despite their young age they may have already acquired knowledge about healthy living habits, which can affect their choices. In fact, in Portugal students are aware of the importance of healthy eating from pre-school onwards (43,66), which may in this case have contributed to the students' acquisition of this prior knowledge. These results are consistent with the results of the questionnaire applied by Schlegel et al. (38) on attitudes towards insects, which concludes that species knowledge is a significant predictor of children's attitudes. Having used foods from the students' daily lives may have influenced their choices due to the high likelihood that they had already acquired some knowledge about the food species used to conduct the interview.

According to our results, exploring the food intraspecific diversity through inquiry based learning and experiential approach seems to promote positive attitudes toward the conservation of intraspecific diversity. After the implementation of the activity, a significant increase in students choosing the biodiverse bag was observed. These positive results towards the conservation of intraspecific diversity after the implementation of an educational activity are similar with other studies' results on children's attitudes towards certain species such as human parasites, birds, reptiles or extensive grassland (34–37). However, the percentage of students who chose the biodiverse bag in the post-test (33.33%) suggests that the approach could be improved. Future studies may try to further explore the effect of intraspecific diversity on the ability of species to resist diverse ecological conditions (see possible activities at https://bit.ly/3ZgIidD and http://bit.ly/3EwIHkn) and adapt to climate change, a dimension not addressed in this educational activity. In our results, the change in the behavioral intention of the students was frequently associated with the cognitive component factors and mostly the 'biology and health knowledge' factor, reinforcing the impact of our educational activity. Similar results were obtained in previous studies where the learning achieved during educational activities directly and/or indirectly influenced students' attitudes towards specific species (34–37,67).

A decrease in the reference to affective component factors, with a significant decrease in the 'emotional' factor, was also observed. Similar results were obtained by Asshoff et al. (34), in their study on attitudes towards bedbugs. A possible explanation for these results could be the impact of students' involvement on their argumentation skills. In fact, according to the ELM, involvement induces differences in the extent of information processing activity, allowing information to be processed as arguments (33). Given this, the students engagement in our educational activity, (designed so that students can assign a personal relevance to the topic, and explore and work with the scientific information), may have influenced their attitude, and contributed to their ability to present more robust arguments to support their ideas. This may have resulted in the observed increased reference to factors of the cognitive component. On the other hand, by enabling each student to assign personal relevance to the varieties of vegetables that they themselves tasted and classified, the educational activity may have fostered the emotional engagement needed for them to engage more strongly in the processing of arguments favoring the conservation of intraspecific diversity. Given this, it is not possible to say that the affective component is not present in students' attitudes or as these may simply not have been mentioned them given the acquisition of cognitive arguments that the students may see as stronger or more convincing. To overcome this problem in our study design, in future studies it would be valuable to add questions to the semi-structured interview specifically addressing the emotional component of attitudes, to fully understand the students' justifications. Additionally, our results support that attitudes towards intraspecific diversity may be more easily transferred between species than food preferences (46), since the bean varieties used in the pre- and post-test were never mentioned during the educational activity. The transfer of attitudes towards intraspecific diversity in different species needs to be further studied. Furthermore, it would also be interesting that future studies involve a larger number of participants to test the association between the different components of attitudes towards intraspecific diversity conservation.

Besides the number of participants, our study has other limitations that deserve discussion. We used a semi-structured interview to collect the students' answers, however the use of a more structured interview may have benefits for data analysis. Namely, as we previously discussed, adding a question for each component of the attitudes would ensure that all students would express themselves about each of the components, providing a better overview of their attitudes. On the other hand, the replicability of this activity in other populations needs to be studied. The same holds truth for the stability of the effect over time of the educational activity's impacts. Our results do not allow us to know how stable is the effect of the activity over longer periods and future studies should consider follow-up studies after longer periods of time.

In future studies, factors such as the frequency of contact with nature or the characteristics of the areas where children live would also be interesting to be analyzed to study if these affects attitudes towards intraspecific diversity conservation, as has been studied for biodiversity conservation (39) or for environmental awareness (68,69). Additionally, it would be interesting to study whether students' health and eating habits impact their attitudes towards intraspecific diversity conservation, as this information could contribute to the development of new approaches to biodiversity conservation education. An important additional limitation of our study is related with the lack of information relative to the acceptance and use of activities such as the one presented here by elementary school teachers. Although the activity here reported is aligned with Portuguese official standards for these grade levels it would be important to study if and how elementary school teachers would perform this activity in their classrooms and if the results here reported would hold truth in this case. This would argue for a study on this educational activity led by teachers, using equipment available in schools, to test its effectiveness in the real world and to enable more teachers to adopt this educational activity.

Conclusions

Our findings suggest that inviting elementary school students to explore intraspecific diversity of food through an educational activity could be a promising new approach to foster positive attitudes towards intraspecific diversity conservation. This educational activity could be applied to other vegetables or fruits. To the best of the authors' knowledge, this is the first study that has developed an analysis framework to assess students' attitudes towards the conservation of intraspecific diversity, assessed students' attitudes towards the conservation of intraspecific diversity, and evaluated the impact of an educational activity on students' attitudes towards the conservation of intraspecific diversity. Our results revealed that elementary school students when choosing intraspecific diversity mostly justify their choices with reference to factors in the cognitive component of attitudes and when choosing one variety mostly justify their choices with reference to emotional factors in the affective component of attitude. Our educational activity increased the number of students who chose biodiversity and consequently the reference to the knowledge factor, while a decrease in the reference to the emotional factor was observed. This points to new directions for future research on factors that influence children's attitudes toward intraspecific diversity conservation. Moreover, it suggests new approaches to enhance public support for intraspecific diversity conservation measures in agricultural species that are fundamental to ensure food security.

Acknowledgements

We would like to acknowledge the teachers, the students who participated in this study, along with their parents, and the school board team for allowing us to perform this study.

References

1. Barnosky AD, Matzke N, Tomiya S, Wogan GOU, Swartz B, Quental TB, et al. Has the Earth's sixth mass extinction already arrived? Nature. 2011 Mar 3;471(7336):51–7.

2. Albert JS, Destouni G, Duke-Sylvester SM, Magurran AE, Oberdorff T, Reis RE, et al. Scientists' warning to humanity on the freshwater biodiversity crisis. Ambio. 2021 Jan;50(1):85–94.

3. Mammola S, Cardoso P, Culver DC, Deharveng L, Ferreira RL, Fišer C, et al. Scientists' Warning on the Conservation of Subterranean Ecosystems. BioScience. 2019 Aug 1;69(8):641–50.

4. Williams-Subiza EA, Epele LB. Drivers of biodiversity loss in freshwater environments: A bibliometric analysis of the recent literature. Aquat Conserv Mar Freshw Ecosyst. 2021 Sep;31(9):2469–80.

5. Ceballos G, Ehrlich PR, Dirzo R. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. Proc Natl Acad Sci [Internet]. 2017 Jul 25 [cited 2022 Dec 27];114(30). Available from: https://pnas.org/doi/full/10.1073/pnas.1704949114

6. Gray A. The ecology of plant extinction: rates, traits and island comparisons. Oryx. 2019 Jul;53(3):424–8.

7. Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, et al. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. Lamb EG, editor. PLOS ONE. 2017 Oct 18;12(10):e0185809.

8. Ripple WJ, Wolf C, Newsome TM, Galetti M, Alamgir M, Crist E, et al. World Scientists' Warning to Humanity: A Second Notice. BioScience. 2017 Dec 1;67(12):1026–8.

9. Cardinale BJ, Duffy JE, Gonzalez A, Hooper DU, Perrings C, Venail P, et al. Biodiversity loss and its impact on humanity. Nature. 2012 Jun 7;486(7401):59–67.

10. United Nations. Sustainable Development Goals - United Nations. United Nations; 2015.

11. Glowka L, Burhenne-Guilmin F, Synge H. A guide to the Convention on Biological Diversity. Gland, Switzerland: IUCN--the World Conservation Union; 1994. 161 p. (Environmental policy and law paper).

12. Bermudez GMA, Lindemann-Matthies P. "What Matters Is Species Richness"—High School Students' Understanding of the Components of Biodiversity. Res Sci Educ. 2020 Dec;50(6):2159–87.

13. Lindemann-Matthies P, Constantinou C, Junge X, Köhler K, Mayer J, Nagel U, et al. The integration of biodiversity education in the initial education of primary school teachers: four comparative case studies from Europe. Environ Educ Res. 2009 Feb;15(1):17–37.

14. Menzel S, Bögeholz S. The Loss of Biodiversity as a Challenge for Sustainable Development: How Do Pupils in Chile and Germany Perceive Resource Dilemmas? Res Sci Educ. 2009 Aug;39(4):429–47.

15. Campos R, Sá-Pinto A. Early evolution of evolutionary thinking: teaching biological evolution in elementary schools. Evol Educ Outreach. 2013 Dec;6(1):25.

16. Des Roches S, Pendleton LH, Shapiro B, Palkovacs EP. Conserving intraspecific variation for nature's contributions to people. Nat Ecol Evol. 2021 Mar 1;5(5):574–82.

17. Gormley K, Birdsall S, France B. Same, same but different! Exploring children's understandings of within-species variation. J Biol Educ. 2022 Aug 5;1–22.

18. Frankham R, Briscoe DA, Ballou JD. Introduction to conservation genetics. Cambridge, UK ; New York: Cambridge University Press; 2002. 617 p.

19. Hallgrímsson B, Hall BK. Variation and Variability. In: Variation [Internet]. Elsevier; 2005 [cited 2022 Oct 7]. p. 1–7. Available from: https://linkinghub.elsevier.com/retrieve/pii/B978012088777450003X

20. Des Roches S, Post DM, Turley NE, Bailey JK, Hendry AP, Kinnison MT, et al. The ecological importance of intraspecific variation. Nat Ecol Evol. 2017 Dec 4;2(1):57–64.

21. Morales-Castilla I, García de Cortázar-Atauri I, Cook BI, Lacombe T, Parker A, van Leeuwen C, et al. Diversity buffers winegrowing regions from climate change losses. Proc Natl Acad Sci. 2020 Feb 11;117(6):2864–9.

22. Baniszewski J, Burton A, Kemanian AR, Roth G, Tooker J. Wheat intraspecific diversity suppressed diseases with subdued yield, economic return and arthropod predation services. Agric Ecosyst Environ. 2021 Aug;315:107438.

23. Snyder LD, Gómez MI, Power AG. Crop Varietal Mixtures as a Strategy to Support Insect Pest Control, Yield, Economic, and Nutritional Services. Front Sustain Food Syst. 2020 May 6;4:60.

24. de Haan S, Burgos G, Liria R, Rodriguez F, Creed-Kanashiro HM, Bonierbale M. The Nutritional Contribution of Potato Varietal Diversity in Andean Food Systems: a Case Study. Am J Potato Res. 2019 Apr;96(2):151–63.

25. Nankya R, Mulumba JW, Lwandasa H, Matovu M, Isabirye B, De Santis P, et al. Diversity in Nutrient Content and Consumer Preferences of Sensory Attributes of Peanut (Arachis hypogaea L.) Varieties in Ugandan Agroecosystems. Sustainability. 2021 Mar 2;13(5):2658.

26. Kyle Jr WC. Youth are demanding action regarding climate change: will educators have the wisdom and courage to respond? APEduC Rev-Investig E Práticas Em Educ Em Ciênc Matemática E Tecnol. 2020;1(1):150–60.

27. Breckler SJ. Empirical validation of affect, behavior, and cognition as distinct components of attitude. J Pers Soc Psychol. 1984;47(6):1191–205.

28. Gifford R, Nilsson A. Personal and social factors that influence pro-environmental concern and behaviour: A review. Int J Psychol. 2014;49(3):141–57.

29. Kollmuss A, Agyeman J. Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res. 2002 Aug;8(3):239–60.

30. Li D, Zhao L, Ma S, Shao S, Zhang L. What influences an individual's pro-environmental behavior? A literature review. Resour Conserv Recycl. 2019 Jul;146:28–34.

31. Jalil NJ, Sharif ZM. Factors Affecting the Awareness of Biodiversity Conservation Among Students in Malaysia Private University. Int J Eng Technol. 2018 Nov 30;7(4.35):791.

32. Levine DS, Strube MJ. Environmental Attitudes, Knowledge, Intentions and Behaviors Among College Students. J Soc Psychol. 2012 May;152(3):308–26.

33. Petty RE, Wegener DT. The Elaboration Likelihood Model: Current status and controversies. In: Dual process theories in social psychology. New York: Guilford Press; 1999. p. 41–72.

34. Asshoff R, Hallerbach P, Reinhardt K. Teaching changes interest and attitudes of students towards bedbugs. Int J Sci Educ. 2020 Jul 23;42(11):1818–33.

35. White RL, Eberstein K, Scott DM. Birds in the playground: Evaluating the effectiveness of an urban environmental education project in enhancing school children's awareness, knowledge and attitudes towards local wildlife. Ito E, editor. PLOS ONE. 2018 Mar 6;13(3):e0193993.

36. Fonseca CA, Sá-Pinto X, Dinis HA, Vasconcelos R. Shooting skinks for good: Producing a movie improves attitudes towards a threatened species. Sci Total Environ. 2021 Oct;791:148356.

37. Špur N, Škornik S, Šorgo A. Influence of experience, interest, knowledge and learning source on children's attitudes towards extensive grassland conservation. Environ Conserv. 2020 Jun;47(2):130–7.

38. Schlegel J, Breuer G, Rupf R. Local Insects as Flagship Species to Promote Nature Conservation? A Survey among Primary School Children on Their Attitudes toward Invertebrates. Anthrozoös. 2015 Jun;28(2):229–45.

39. Rosalino LM, Gheler-Costa C, Santos G, Gonçalves MT, Fonseca C, Leal AI. Conservation priorities for elementary school students: Neotropical and European perspectives. Biodivers Conserv. 2017 Oct;26(11):2675–97.

40. Bruckermann T, Fiedler D, Harms U. Identifying precursory concepts in evolution during early childhood – a systematic literature review. Stud Sci Educ. 2021 Jan 2;57(1):85–127.

41. Pinela J, Barros L, Carvalho AM, Ferreira ICFR. Nutritional composition and antioxidant activity of four tomato (Lycopersicon esculentum L.) farmer' varieties in Northeastern Portugal homegardens. Food Chem Toxicol. 2012 Mar;50(3–4):829–34.

42. Podsędek A, Wilska-Jeszka J, Anders B, Markowski J. Compositional characterisation of some apple varieties. Eur Food Res Technol. 2000 Feb 1;210(4):268–72.

43. Education Ministry. Primary education national curriculum – essential skills [Internet]. Portugal: Primary Education Department; 2001. Available from: https://www.cfaematosinhos.eu/NPPEB_01_CN.pdf

44. Greek educational system. Government's Gazette Vol. B, No. 304/13–03-03 [Internet]. Available from: https://www.alfavita.gr/sites/default/files/attachments/didaktea_ili.pdf

45. Italian educational system. Indicazioni nazionali per il curricolo della scuola dell'infanzia e del primo ciclo d'istruzione (D.M. 254 del 16 novembre 2012) [Internet]. Available from: https://indicazioninazionali.it/

46. Authors

47. Vadiveloo M, Principato L, Morwitz V, Mattei J. Sensory variety in shape and color influences fruit and vegetable intake, liking, and purchase intentions in some subsets of adults: A randomized pilot experiment. Food Qual Prefer. 2019 Jan;71:301–10.

48. Duschl RA, Schweingruber HA, Shouse AW, National Research Council (U.S.), National Research Council (U.S.), National Research Council (U.S.), editors. Taking science to school:

learning and teaching science in grades K-8. Washington, D.C: National Academies Press; 2007. 387 p.

49. National Research Council (U.S.), editor. A framework for K-12 science education: practices, crosscutting concepts, and core ideas. Washington, D.C: The National Academies Press; 2012. 385 p.

50. Darbellay C, Luisier JL, Villettaz JC, Amadó R, Azodanlou R. Changes in flavour and texture during the ripening of strawberries. Eur Food Res Technol. 2004 Jan 1;218(2):167–72.

51. Thomas A, Sulli C, Davidson E, Berdougo E, Phillips M, Puffer BA, et al. The Bitter Taste Receptor TAS2R16 Achieves High Specificity and Accommodates Diverse Glycoside Ligands by using a Two-faced Binding Pocket. Sci Rep. 2017 Aug 10;7(1):7753.

52. Conrad Z, Raatz S, Jahns L. Greater vegetable variety and amount are associated with lower prevalence of coronary heart disease: National Health and Nutrition Examination Survey, 1999–2014. Nutr J. 2018 Dec;17(1):67.

53. Mennella JA. Ontogeny of taste preferences: basic biology and implications for health. Am J Clin Nutr. 2014 Mar 1;99(3):704S-711S.

54. He Y, Wang X, Chen J. Current Perspectives on Food Oral Processing. Annu Rev Food Sci Technol. 2022 Mar 25;13(1):167–92.

55. Rogers N. Why illness might leave a bitter taste in the mouth. Nature. 2015 Apr 29;nature.2015.17415.

56. Cohen L, Manion L, Morrison K. Research Methods in Education. 8th Edition. New York: Routlegde; 2018.

57. van Riper CJ, Kyle GT, Sherrouse BC, Bagstad KJ, Sutton SG. Toward an integrated understanding of perceived biodiversity values and environmental conditions in a national park. Ecol Indic. 2017 Jan;72:278–87.

58. Verma AK. Biodiversity: Its Different Levels and Values. Int J Environ Sci. 2016;7(2):143–5.

59. McHugh ML. Interrater reliability: the kappa statistic. Biochem Medica. 2012;276–82.

60. Stemler SE. A Comparison of Consensus, Consistency, and Measurement Approaches to Estimating Interrater Reliability. 2004 [cited 2022 Oct 4]; Available from: https://scholarworks.umass.edu/pare/vol9/iss1/4/

61. Lahm K. Validity, quantitative. In: The blackwell encyclopedia of sociology. Singapore: The blackwell encyclopedia of sociology; 2007.

62. Miralles A, Raymond M, Lecointre G. Empathy and compassion toward other species decrease with evolutionary divergence time. Sci Rep. 2019 Dec;9(1):19555.

63. Kontsiotis VJ, Rapti A, Liordos V. Public attitudes towards venomous and non-venomous snakes. Sci Total Environ. 2022 Jul;831:154918.

64. Koh DCI, Armugam A, Jeyaseelan K. Snake venom components and their applications in biomedicine. Cell Mol Life Sci. 2006 Dec;63(24):3030–41.

65. Pandey DP, Subedi Pandey G, Devkota K, Goode M. Public perceptions of snakes and snakebite management: implications for conservation and human health in southern Nepal. J Ethnobiol Ethnomedicine. 2016 Dec;12(1):22.

66. Directorate General of Education. Curricular Guidelines for Pre-School Education [Internet]. Ministry of Education; 2016. Available from: http://www.dge.mec.pt/ocepe/index.php/node/83

67. MacDonald E, Milfont T, Gavin M. Applying the Elaboration Likelihood Model to increase recall of conservation messages and elaboration by zoo visitors. J Sustain Tour. 2016 Jun 2;24(6):866–81.

68. Nancy M. Wells, Kristi S. Lekies. Nature and the Life Course: Pathways from Childhood Nature Experiences to Adult Environmentalism. Child Youth Environ. 2006;16(1):1–24.

69. Rosa CD, Profice CC, Collado S. Nature Experiences and Adults' Self-Reported Pro-environmental Behaviors: The Role of Connectedness to Nature and Childhood Nature Experiences. Front Psychol. 2018 Jun 26;9:1055.

Supporting Information

S1 Table. McNemar tests results to test for significant differences between pre- and post-tests results for each of the categories of analysis in control and target groups. Asterisks (*) denote post-test values that significantly differ from pretests according to McNemar test results ($p < .05$). K1 to K8 are different biology and health knowledge topics addressed in the educational activity. Namely, K1 - Different varieties of a vegetal species have different properties (different varieties have distinct tastes, different varieties may have distinct features that make them more suitable for distinct dishes, different varieties have different nutritional properties and make our diet more diverse); K2 - Different varieties may grow and produce differently in distinct environments; K3 - The food's degree of ripeness alters its flavor; K4 - Different people have distinct tastes and preferences; K5 - It is healthy to eat distinct varieties of a vegetable and/or it is not healthy to always eat the same variety of a vegetable; K6 - Our tastes change over time, so we should try different varieties of vegetables; K7 - The way we chew food influences the taste we get from it; K8 - The fact that an individual is sick can change the way they taste food.

S2 Table. Chi-square tests results to study possible associations between affective and cognitive components with the students' behavioral intention in pre- and post-tests. K1 to K8 are different biology and health knowledge topics addressed in the educational activity.

Namely, K1 - Different varieties of a vegetal species have different properties (different varieties have distinct tastes, different varieties may have distinct features that make them more suitable for distinct dishes, different varieties have different nutritional properties and make our diet more diverse); K2 - Different varieties may grow and produce differently in distinct environments; K3 - The food's degree of ripeness alters its flavor; K4 - Different people have distinct tastes and preferences; K5 - It is healthy to eat distinct varieties of a vegetable and/or it is not healthy to always eat the same variety of a vegetable; K6 - Our tastes change over time, so we should try different varieties of vegetables; K7 - The way we chew food influences the taste we get from it; K8 - The fact that an individual is sick can change the way they taste food.

S3 Table. Description and examples of the various topics of the 'biology and health knowledge' factor. Underscore (_) denotes that no examples of the specific topic of the 'biology and health knowledge' factor were found in the students' answers.

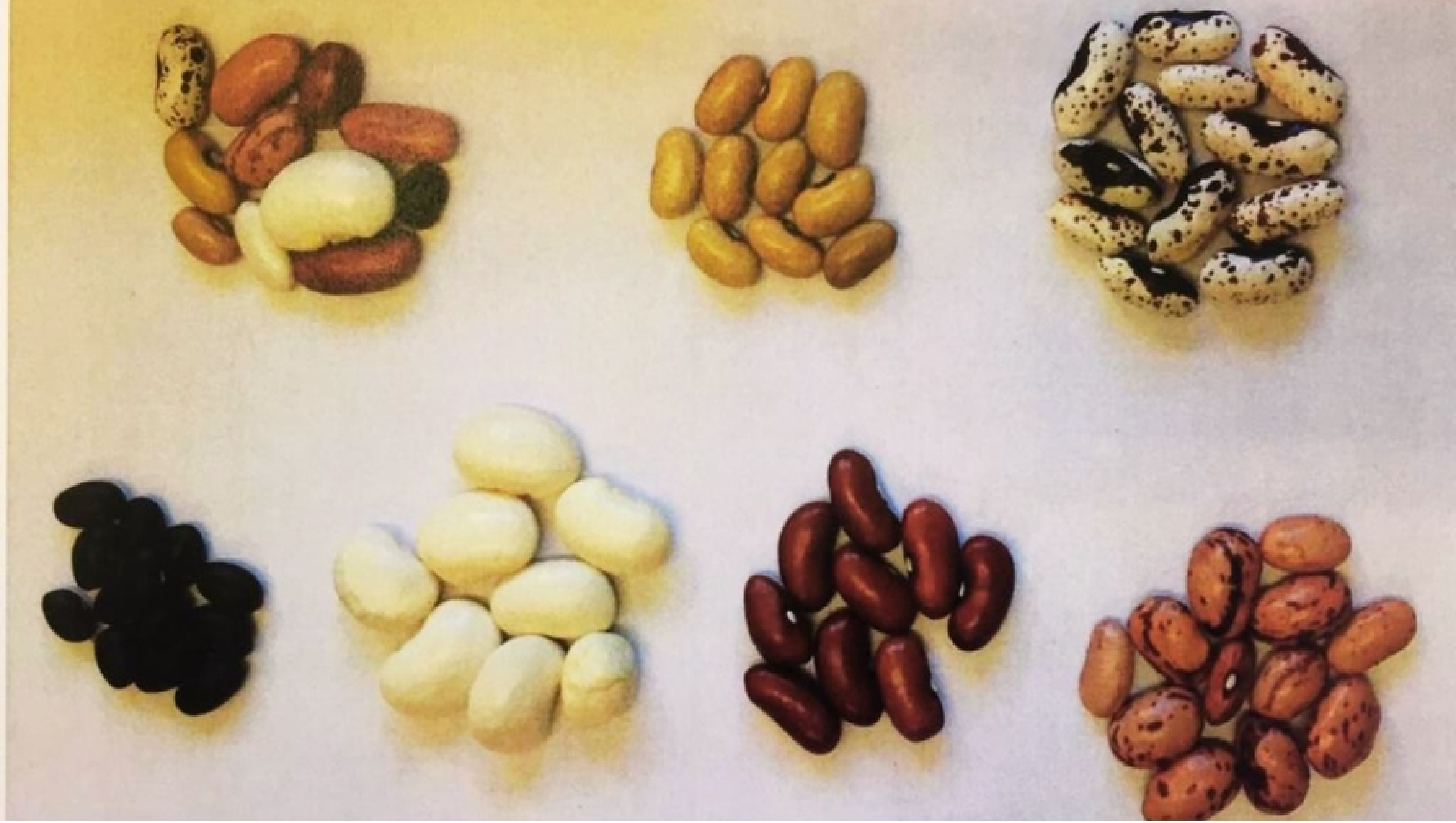
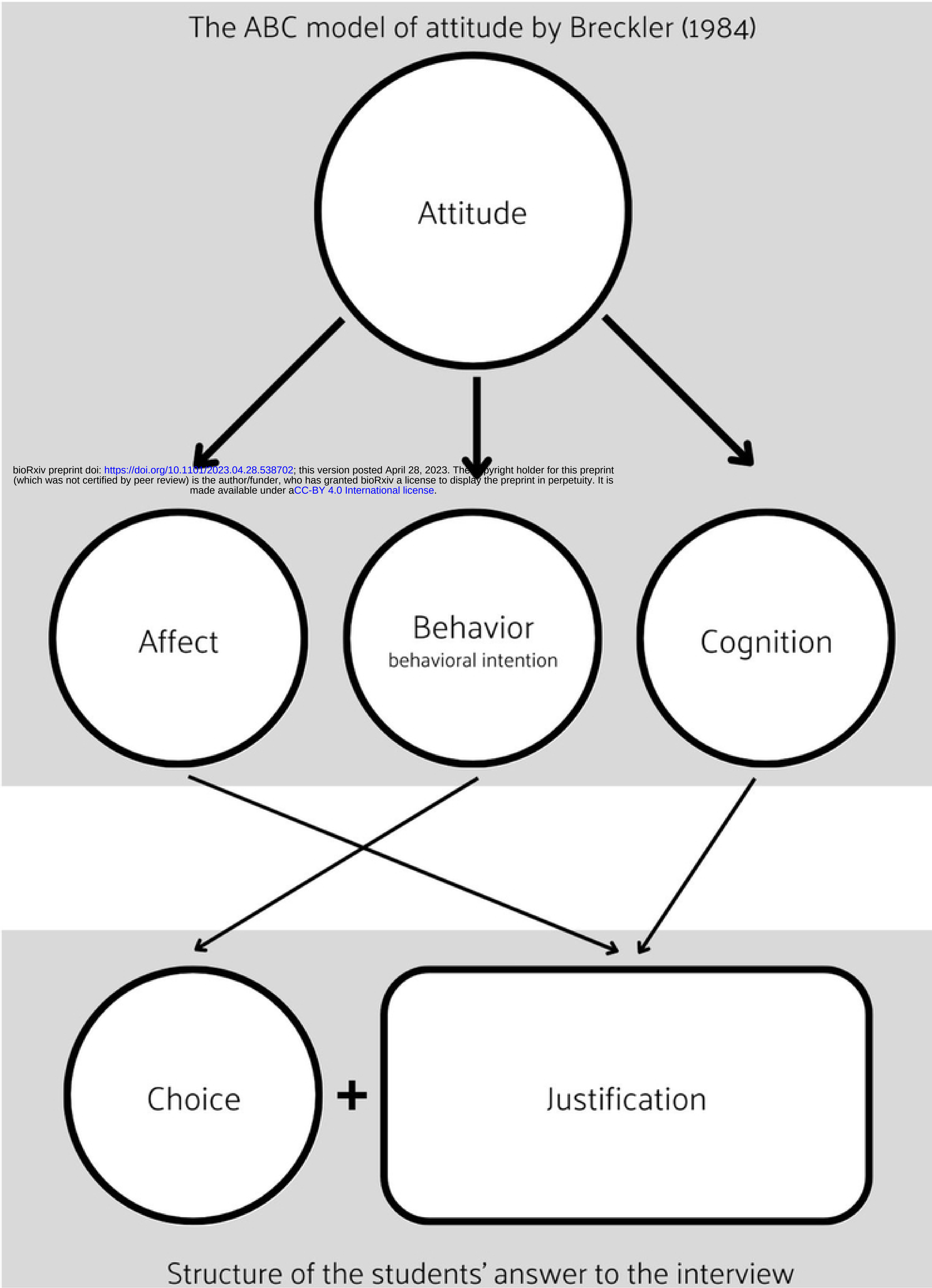


Fig 1



The ABC model of attitude by Breckler (1984)
Attitude
Affect
Behavior
behavioral intention
Cognition
Choice
+
Justification
Structure of the students' answer to the interview

Fig 2

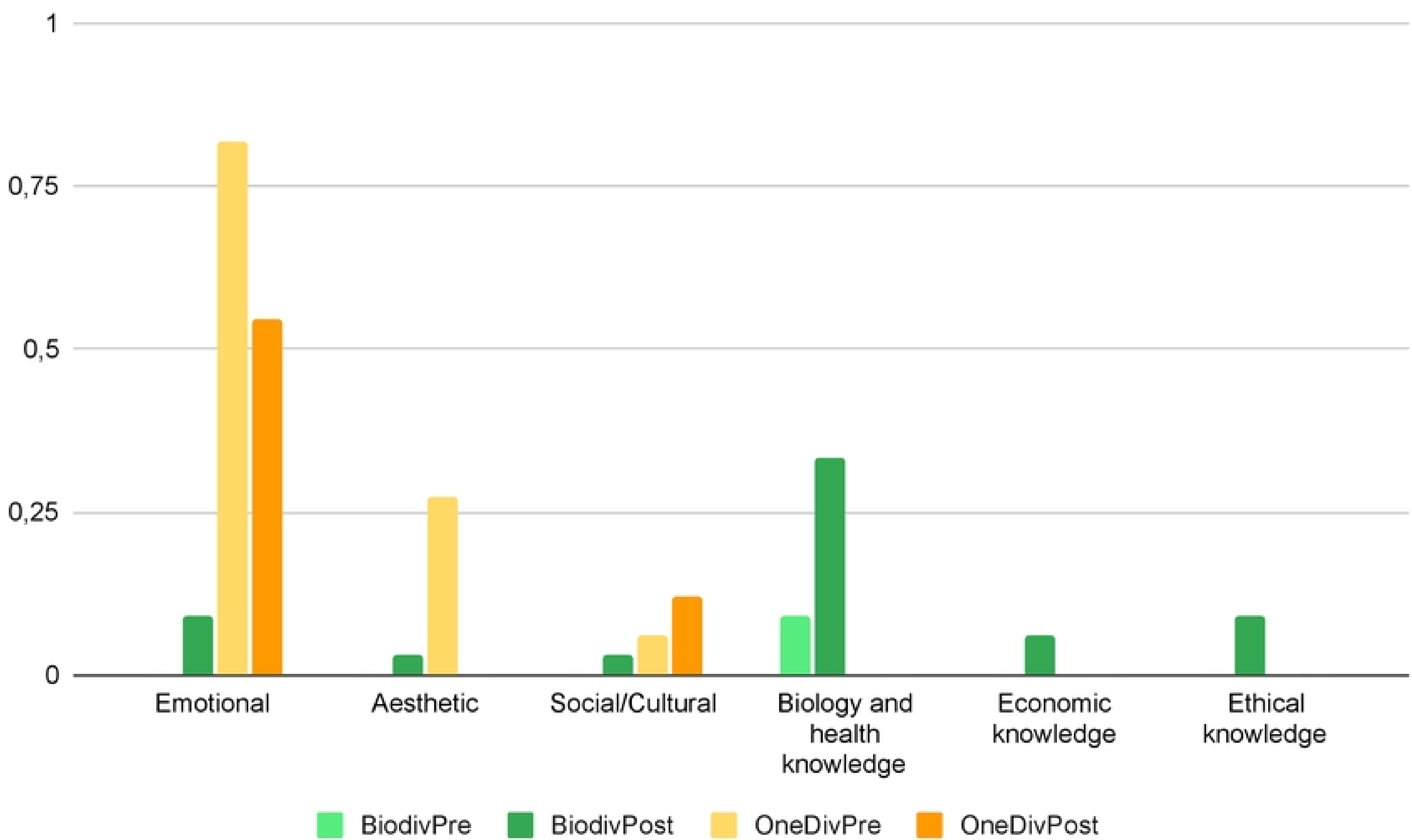

1
0,75
0,5
0,25
0
Emotional
Aesthetic
Social/Cultural
Biology and health knowledge
Economic knowledge
Ethical knowledge
BiodivPre
BiodivPost
OneDivPre
OneDivPost

Fig 3

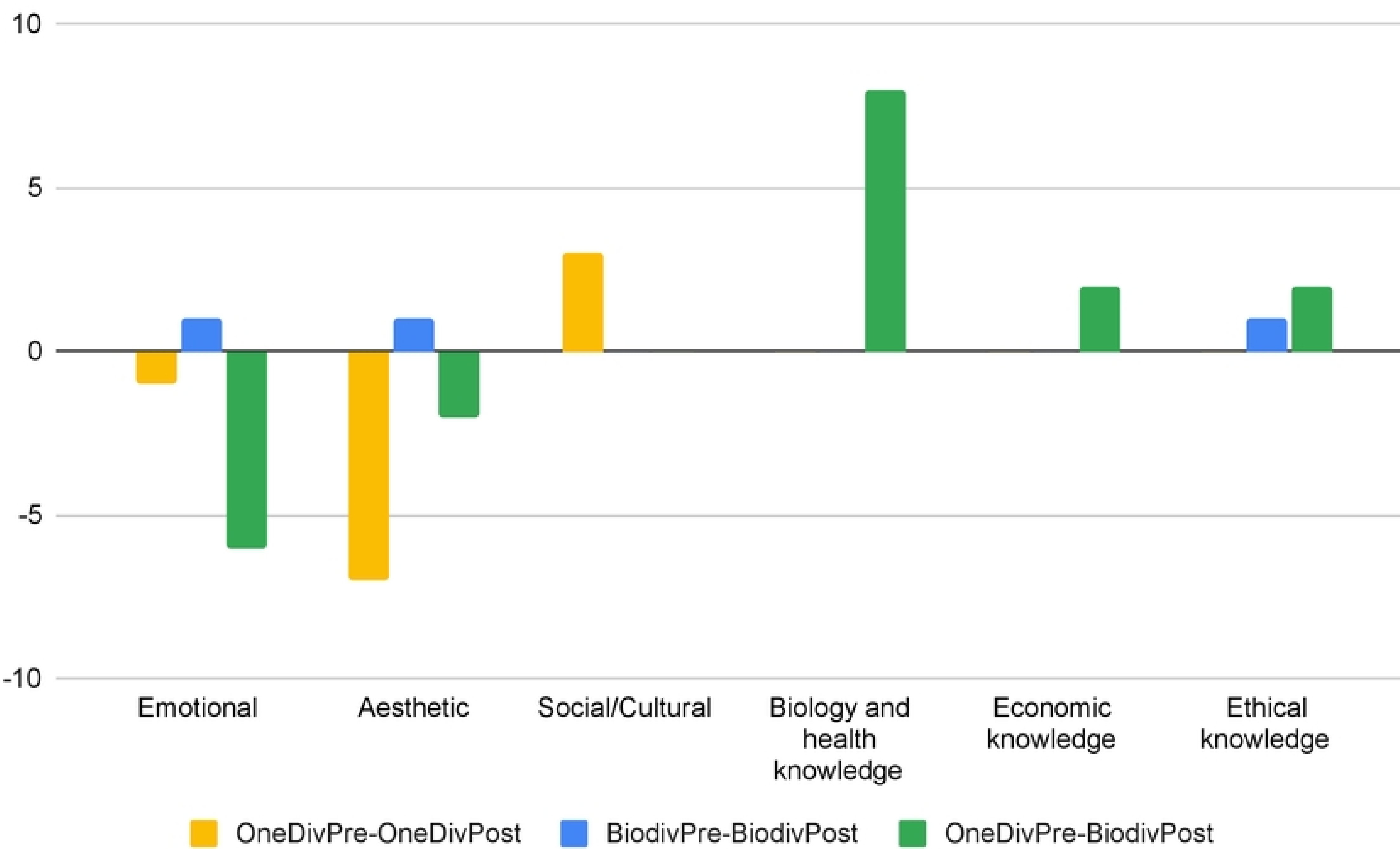

10
5
0
-5
-10
Emotional
Aesthetic
Social/Cultural
Biology and health knowledge
Economic knowledge
Ethical knowledge
OneDivPre-OneDivPost
BiodivPre-BiodivPost
OneDivPre-BiodivPost

Fig 4