Good practice report

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Chemistry revisited: a teacher training workshop on nutrition

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Abstract: This work presents a teaching training workshop on human nutrition topics with strong emphasis on the underlying chemical concepts. It was designed according to the Sustainable Conscious Cognitive Learning Model (SCCLM) and framed in a Context-Based Science Education (CBSE) approach. The proposal was implemented with 44 upper secondary school science teachers. It consisted of three phases. First, teachers were presented with 'common-sense' driven sentences on nutrition topics and they were asked if they agreed or disagreed with them. Through an oral discussion, the emergence of the teacher's own cognitive conflicts was promoted in order to trigger subsequent motivation for achieving further knowledge. Next, main scientific ideas and related chemical concepts were presented for each sentence, along with teaching recommendations to complete a CBSE approach. Finally, teachers were asked their opinions on the didactic proposal. Results showed that teachers were motivated to learn beyond their strong initial non-scientific based ideas by questioning the reliability of the information sources. They were also willing to revisit their teaching on some of the canonical concepts of chemistry.

Keywords: chemistry in context; conceptual change; nutrition; secondary school.

Introduction

In recent decades, worldwide concern about eating habits of children and teenagers has increased (Losada, Leonardelli, & Magliola, 2015; WHO, 2013). Since media and social interaction are strong habit-makers (Cashdan, 1994; Lanigan, 2012; McCaughtry, Fahlman, Martin, & Shen, 2011; Nicklaus, 2009; Pozo Tamayo & Cubero Juánez, 2015), inaccurate sources of information can give rise to appropriation of scientifically incorrect knowledge concerning nutrition (Brown, Ioannidis, Cope, Bier, & Allison, 2014).

Research has shown that school nutrition education programs are effective in promoting healthy eating behaviors (Dudley, Cotton, & Peralta, 2015; Johnson & Johnson, 1985). Thus, teachers can play a significant role in food habit formation (Epstein, 2018; Roccaldo, Censi, D'Addezio, Berni Canani, & Gennaro, 2017). However, the limited number of studies available on teachers' nutrition knowledge have shown poor understanding and lack of effective methods for teaching this subject (Jones & Zidenberg-Cherr, 2015; Petersen & Kies, 1972; Sharma et al., 2013; Soliah, Newell, Vaden, & Dayton, 1983). In previous work, we applied a survey to 20 high school science teachers on topics of *human nutrition* and results showed that their ideas and arguments were mostly not based on scientific information (Edelsztein & Galagovsky, 2019).

This work presents a teaching training experience on topics from *human nutrition* with a strong emphasis on the underlying chemical concepts. The experience consisted of a 3 h training workshop for 44 upper

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secondary school science teachers. It was designed according to the Sustainable Conscious Cognitive Learning Model (SCCLM) (Galagovsky, 2004a, 2004b) and framed in a Context-Based Science Education (CBSE) approach.

Didactic theoretical framework

Many studies concerning natural sciences syllabus recommend the CBSE approach which promotes teaching scientific concepts by addressing real problems from an interdisciplinary perspective (Bennett, Lubben, & Hogarth, 2007; Caamaño, 2011, 2015; Gilbert, Bulte, & Pilot, 2011; Marchán & Sanmartí, 2015; Meroni, Copello, & Paredes, 2015; Edelsztein, Tarzi, & Galagovsky, 2020). The main goal is to motivate students toward science issues; however, impediments to bring about teacher's involvement have been reported (Gómez Crespo, Pozo, & Gutiérrez Julián, 2004; Pozo & Gómez Crespo, 1998, Pérgola & Galagovsky, 2020). Therefore, a big support is needed to help them face any CBSE approach (Eilks, Parchmann, Gräsel, & Ralle, 2004; Gräsel & Parchmann, 2004; Parchmann et al., 2006; Pilling, Holman, & Waddington, 2001).

Many researchers have proposed that *conceptual change* on scientific contents can be accomplished when individuals are aware of cognitive conflicts coming from controversial information (Posner, Strike, Hewson, & Gertzog, 1982; Pozo, 2007; Sinatra & Pintrich, 2003; Vosniadou, 2007). The Sustainable Conscious Cognitive Learning Model (SCCL) (Galagovsky, 2004a, 2004b) proposes that a subject's cognitive conflict arises when at least two pieces of contradictory information, that may be both potentially correct, are processed simultaneously in his/her working memory (Johnstone, 1997). Consequently, SCCL poses that an important issue in class is not only to explore subjects' previous ideas but also their origin and supporting argumentation. The awareness about diversity of different, but possibly correct, information coming from all the arguments of his/her classmates (i.e. to face understandable contradictory information) is highly motivating since it can trigger the desire to search for the appropriate scientific information.

Objectives

The general aim of this work has been to develop and implement an innovative structure of class activities for teacher training concerning topics on *human nutrition* in order to revisit some important chemistry concepts.

The specific objectives of this work have been:

- To present an instrument related to *human nutrition*, so that teachers could express their own ideas and beliefs, in order to further being aware of contradictory ideas and arguments.
- To improve teacher´s argumentative skills by promoting active participation.
- To develop the need of knowing the undelying chemistry concepts related to topics on *human nutrition.*

Workshop activities: phases and expectations

The workshop consisted of three phases:

Phase 1 (45 min)

A structured Initial Survey (IS) was designed to **reveal teachers' common-sense ideas and/or beliefs and their supporting arguments** (Edelsztein & Galagovsky, 2019). It consisted of a grid with six sentences related to *human nutrition*. Teachers were asked to indicate their opinions within four categories related to their degree of agreement or disagreement regarding the sentences (Table 1), along with a brief argument to support each of their choices. The four categories were:

- *Totally disagreement* (TD), that is in complete disagreement with the statement.

Table 1: The six sentences of the Initial Survey (IS) are shown in the left column. Percentages of answers involving four categories (totally disagreement (TD), quite disagreement (QD), quite agreement (QA) or totally agreement (TA)) are indicated (n = 44).

Sentence	%TD	%QD	%QA	%TA
(1) It is necessary to drink two liters of water per day.	0.0	4.5	38.6	56.8
(2) A natural option to prevent colds is to consume large amounts of vit C.	9.1	15.9	34.1	40.9
(3) It is essential to eat carrots to ensure good vision.	13.6	27.3	34.1	25.0
(4) When preparing fried foods, use as little oil as possible in your cooking.	11.4	13.6	22.7	52.3
(5) Brown eggs are more nutritious than white eggs.	31.8	27.3	29.5	11.4
(6) It is convenient to choose cholesterol-free oils for cooking.	31.8	22.7	25.0	20.5

- *Quite disagreement* (QD), that is mostly in disagreement but not completely, maybe because they agree with one part of the sentence but not with the other or because they did not have enough evidence to support their arguments.
- *Quite agreement* (QA), that is, mostly in agreement but not completely, again maybe because they were unsure about the evidence to support their arguments or because they disagree with some part of the sentence.
- *Totally agreement* (TA), that is in complete agreement with the statement.

After 15 min, these written documents were collected by the workshop coordinator for later further analysis. Table 1 shows the teachers' choices to the IS.

During the subsequent 30 min, in order to **promote the emergence of individual cognitive conflicts**, each sentence was read aloud and participants had to raise their hands according to their choices and explain their arguments. The coordinator wrote all of them on the board. Teachers' ideas along with the diversity of their arguments were strongly highlighted during this activity, avoiding either discussion or scientific questioning.

At the end of this phase participant were asked if anyone had changed their mind based on other's arguments.

The diversity of answers was an expected outcome along with the accomplishment of the first two specific objectives.

Phase 2 (120 min)

Once all the participants' arguments were displayed and their diversity highlighted, the workshop coordinator distributed printed scientific material, explained some concepts and presented simple experiments with everyday materials.

Phase 2 focused on providing the necessary underpinning scientific information to achieve a *conceptual change*. This phase provided information based on teachers' demand and motivation to know the scientifically correct arguments that would support -or not- the truthfulness of each of the sentences in Table 1.

The expected outcome for this phase was to promote metacognitive reflections about the participants' own learning process as to accomplish the third specific objective.

Phase 3 (15 min)

Finally, each participant was asked to answer a new printed version of the IS. Results are shown in Table 4 and Figure 1. Teachers were also asked whether they thought they could carry out some of the activities in high school classrooms. Answers were assigned into six categories (Table 5).

The expected outcome for this phase was to evaluate teachers' consciousness about their conceptual change on scientific contents as much as their opinions about the design of teaching activities.

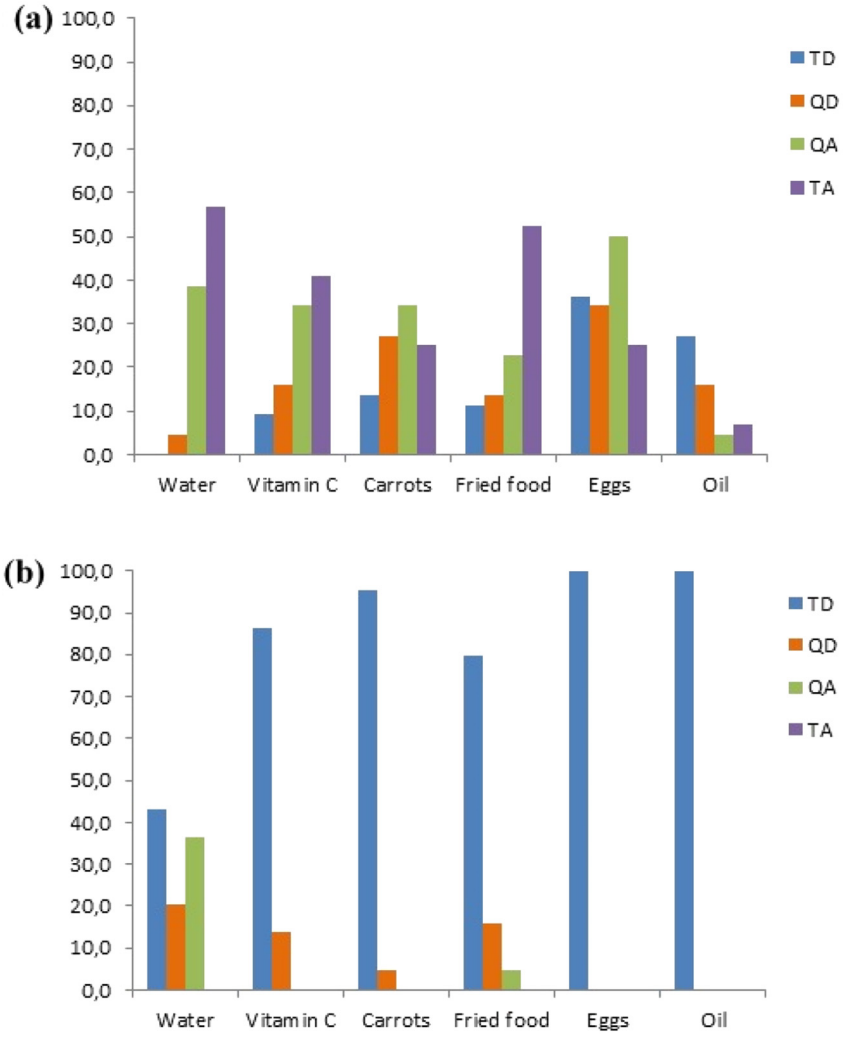

Figure 1: Percentages of choice of each answer for each sentence of the 44 teachers (a) at the beginning of the workshop and (b) at the end of the workshop.

Results and discussion

In this section, results will be shown and discussed following the order of the phases 1 to 3.

Table 1 shows the teachers' choices, based on the written IS.

The diversity of answers was an expected outcome that proved to be necessary for preparing the audience for the last specific objective.

After answering the IS survey, teachers were stimulated to express their arguments to support -or not- each sentence. Two categories could be established: scientific or non-scientific based arguments. Table 2 shows this categorization and some examples. Only 15% of the teachers' choices had a scientific-based background. The majority (85%) of the arguments proved to be assertive sentences based on personal anecdotes.

Teachers who have made unscientific claims have also had vague explanations about the source of their knowledge, in most cases being arguments such as '*It is known*' or '*I / we know*'. The inability to specify a reliable source of information led to an unforeseen new cognitive conflict: the arguments for choosing each option might not have been equally justified. This was particularly interesting towards the end of the phase, when teachers were asked if they had changed their minds after hearing the ideas of others. Results showed that almost no one did it, but many doubted due to not being sure how confident were their sources of information compare to those from other teachers.

Table 2: Categorization of the 207 arguments from the 44 teachers. Percentages and some examples are shown.

Category	%	Examples of representative arguments for each category (respond to sentence #)
Non-scientific based affirmations (stereotypes, common sense, myths, popular knowledge, someone's advice, own's beliefs)	85	Drinking water is a World Health Organisation recommendation (#1)Vitamin C is recommended by doctors (#2)I know that vitamin C prevents colds (#2)Grandma used to tell me to eat carrots for improving my sight (#3)Fried foods increase the chance of having cholesterol so the less you eat, the better (#4)I have read that fried foods are bad for your health so you need to use little oil in their preparation (#4)Brown eggs are more natural and better (#5)We know that eating cholesterol is bad for the body (#6)People say cholesterol is bad but it doesn't seem so terrible to me (#6)
Scientific-based arguments and knowledge from previous learning	15	Colds are caused by viruses (#2)Vitamin C is water soluble and does not accumulate in the body (#2)Vegetal oil does not have cholesterol (#6)

Although personal beliefs proved to be difficult to change even when clearly confronted with others', all teachers were eager to know what the correct answers were.

Next, specific features will be commented for each sentence.

Sentence #1. ***It is necessary to drink two liters of water per day.***

95.4% of the participants stated that they are in quite or completely agreement with this sentence arguing generic ideas like '*It is important to hydrate*'. Among those who fully agreed (TA) one of the most repeated source of opinion referred to recommendations from doctors, publicity, family members; only two teachers were able to identify that: '*It is a World Health Organization recommendation*'.

Among those who quite agreed (QA), the majority simply stated that they were not sure if two liters were the right amount.

Only six teachers out of the 44 mentioned expressed that the amount of water required per day should depend on individual factors. One of them used his own experience to justify it: '*I am a runner and I drink more water when I exercise*'.

Sentence #2. ***A natural option to prevent colds is to consume large amounts of vitamin C.***

75% of the participants completely or quite agreed with the statement (TA or QA). Among those, some of the arguments referred to popular knowledge such as '*My grandmother used to say it*', but the wide majority of them refer to the influence of advertising and their commercial value with a certainly naive look: '*If it wasn't true, they wouldn't sell as many vitamin C products as they do*'. Also, many of them supported their choices with personal anecdotes: '*It worked for me*'.

Eleven teachers indicated that they quite or totally disagreed (QD and TD) with the sentence. Again, many of them relied on personal anecdotes. Only one participant stressed vitamin C is water soluble, therefore she thought that it could not accumulate in the body making it unnecessary to consume large amounts for preventing colds.

None of the teachers doubted about the ability of vitamin C to prevent or cure colds.

Sentence #3. ***It is essential to eat carrots to ensure good vision.***

In this case, the responses were more widespread.

59% of the teachers agreed to some extent with the phrase (TA and QA). Their arguments mainly referred to anecdotal social and family interactions and to information gathered in the media but without scientific arguments that justify the elections. One participant said that '*Carrots have something that helps to see better*',

without any specification. Three of them pointed out the presence of vitamin A in carrots while just only one referred to the β-carotenes as the actual precursor of vitamin A present in carrots and other foods.

27% of the teachers quite disagreed and 14% completely disagreed with the proposition. One of them argued that '*I know that carotenes improve vision but they are in many vegetables*.' The others' arguments were in line with this. Therefore, the disagreement was not due to questioning the usefulness of carrots for improving vision but rather the fact that many other foods contain carotenes.

Sentence #4. *When preparing fried foods, use as little oil as possible in your cooking.*

75% of the teachers completely or quite agree (TA or QA) with the belief that using little oil when frying is more convenient. Their arguments refer to the risks of eating a high fat diet.

Among the 25% who quite or totally disagree, the most repeated justification was not really an argument rather an affirmation that '*We shouldn't eat fried foods at all*'. Therefore, the disagreement was not presented in terms of quantities of use but rather of questioning the use itself. None of the teachers acknowledged the thermal and physicochemical processes that occur during frying.

Sentence #5. *Brown eggs are more nutritious than white eggs.*

As with phrase #3, the responses in this case were quite scattered.

In Argentina, brown eggs are usually far more expensive than white ones. 41% of the participants indicated their agreement with this sentence (TA and QA) due to the association between the higher the price, the better nutritional quality.

Among those who disagreed (QD and TD), the majority argument was that '*It is the same because they are just eggs*.'

Sentence #6. *It is convenient to choose cholesterol-free oils to consume.*

45% of the teachers agreed with the phrase to some extent (TA and QA). The arguments mainly refer to health risk, as with sentence #4, such as '*Cholesterol is bad for the heart*'.

Among those who quite disagree with the sentence, most of the justifications referred that '*It is not that bad to eat cholesterol once in a while*'.

Fourteen teachers completely disagree (TD) with the sentence. All of them mentioned the fact that '*Cholesterol is only found in animal products*' therefore it could not be founded in oil.

The first two specific objectives were accomplished during Phase 1 according to authors' expectations since the wide variety of responses and arguments promoted clear cognitive conflicts and teachers proved to be highly motivated to know the actual correct answers.

During Phase 2, the theoretical foundations that support (or not) the truthfulness of each sentence were explained.

Next, main scientific ideas and related chemical concepts are presented for each sentence, along with teaching recommendations to complete a CBSE approach. This information was also delivered to the participants as printed material.

Sentence #1. *It is necessary to drink two liters of water per day.*

– *Theoretical foundations.* In living organisms, water fulfills several functions: solvent, reaction medium, transport function, structural, mechanical buffer and thermoregulator.The two main sources of water for humans are fluid intake (80%) and solid foods (20%) (Kant, Graubard, & Atchison, 2009). Water losses occur mainly by respiration, transpiration and urination. The water loss ratio of each individual is very variable and depends on numerous factors such as room temperature, habits and physical activity. For this reason, the amount of liquid to be consumed *per* day will also depend on these factors and will vary according to the diet, lifestyle and even the age of each individual (Grandjean, 2005; CDC, 2020). Several reference institutions such as the World Health Organization (WHO) and the European Food Safety Authority (EFSA) have made hydration recommendations close to 2 L per day or 1 to 1.5 ml *per* calorie consumed (EFSA, 2010, 2017).The idea that 2 L (that is eight glasses) of water should be taken was born as a recommendation made in 1945 by the Nutrition Council of the United States because that was the average

consumption of liquids of the Americans at that time. However, there is not enough medical evidence that this exactly amount it is needed (Valtin, 2002; Vreeman, & Carroll, 2007).

– *Chemistry revisited*. This sentence could be a trigger to work in the classroom the concepts of solvent, solution, solubility and reaction medium.There is a simple experiment to perform that consists of preparing effervescent tablets. Usually, these tablets are created by compressing a mixture of sodium bicarbonate and solid organic acids such as citric and tartaric acid. Therefore, there is no possible reaction between them until they are thrown into water. Only then, the reagents can dissolve and react to produce carbon dioxide. The tablets can be thrown into different solvents (ethanol, hexane, acetone) to compare the volume of carbon dioxide produced and the velocity of the reaction (as the rate of production and amount of bubbles, for example), allowing further discussion of the concept of solubility regarding to the polarity of the reagents involved and the key role of the reaction medium.Furthermore, this sentence opens up the possibility of discussing what would happen if there were not enough water in the cells, leading to the discussion of concepts such as dry preservation of foods and its relationship with the water activity required for the survival and growth of bacteria and fungi.

Sentence #2. ***A natural option to prevent colds is to consume large amounts of vitamin C.***

– *Theoretical foundations*. Vitamins are essential micronutrients involved in many metabolic and physiological functions in the human body. There are 13 vitamins identified that are classified according to their solubility into fat-soluble vitamins (A, E, D, and K) and water-soluble vitamins (B-group vitamins and vitamin C) (Ball, 2006; Latham, 2002). Vitamin C, also known as L-ascorbic acid, plays several biosynthetic and antioxidant functions and it has an important role in immune function (Jacob & Sotoudeh, 2002), among others. Acute vitamin C deficiency leads to scurvy. Humans, unlike most animals, are unable to synthesize vitamin C endogenously, so it is an essential dietary component (Li & Schellhorn, 2007). The daily requirement of vitamin C, according to the Food and Nutrition Board (FNB) ranges between 85 and 120 mg (Institute of Medicine, 2000). Approximately 70 to 90% of vitamin C is absorbed at moderate intakes of 30–180 mg per day. However, at doses above 1 g per day, absorption falls to less than 50% and not metabolized ascorbic acid is excreted in the urine (Jacob & Sotoudeh, 2002).Where does the link to colds come from? Nobel Prize in Chemistry Linus Pauling spent many years of his life promoting the alleged benefits of vitamin C for common colds (Pauling, 1970a, 1970b, 1976). Since he occupied a prominent position in the scientific community, his proposal led to many studies. But in most cases the conclusions were the same: vitamin C has not shown any signs of preventing flu or colds under normal circumstances (Hemila & Chalker, 2013).
– *Chemistry revisited*. As a first approach, it could be worth discussing in class what makes a chemical compound a vitamin. Then, it may be possible to analyze the chemical structure of the different groups of vitamins and try to predict their preferred solubility in water or in fat in order to link this characteristic with their metabolization and their intake needs (Ball, 2006; Latham, 2002).Furthermore, this sentence could be a trigger to work in the classroom the concepts of oxidation since vitamin C is a known antioxidant. It is also possible to delve into concepts of reaction kinetics. One suitable experiment consists of quantifying the amount of vitamin C in a freshly squeezed orange juice and analyzing whether it changes over time or with increasing temperature (Sowa & Kondo, 2003). A similar method could also be used to find out kinetics parameters (Rahmawati & Bundjali, 2012). From the results of the experiment, it is possible to discuss the effects of the storage of vegetables and fruits on the content of vitamin C as well as the temperature at which it is most convenient to maintain them.

Sentence #3. ***It is essential to eat carrots to ensure good vision.***

– *Theoretical foundations*. Carrots have a relatively high content of β-carotene, a molecule that is also known as provitamin A. After ingestion, it is converted into vitamin A or retinol.In humans, there are two specialized types of photoreceptors cells in the retina: rods, almost entirely responsible for night vision, and cones, primarily responsible for color vision. To detect light, rods exploit the unique properties of 11-cis retinal, a vitamin A-derived visual chromophore, that is covalently bound to an opsin signaling

protein. In the presence of light, 11-*cis* retinal is isomerized to the *trans* configuration, causing a straightening of the polyene chain and, therefore, changing the shape of the opsin. These rapid movements are transferred to the lipid membrane and nerve cells to which it is attached triggering nerve impulses (Ebrey & Koutalos, 2001; Lintig, Kiser, Golczak, & Palczewski, 2010; Mankoo & Singh, 2001).Vitamin A deficiency is associated with vision defects due to its participation in this mechanism (Latham, 2002; Mactier & Weaver, 2005; WHO, 2009). However, only a small daily amount of vitamin A is needed and when there are enough reserves (which accumulate in the liver), the conversion of carotenes slows down. FAO, WHO and the US National Institutes of Health (NIH) recommend the consumption of about 750 μg of retinol per day for adults (Institute of Medicine, 2001).So, where did the idea that cramming with carrots improve vision? Apparently, it originated during World War II when the British Royal Air Force spread the rumor that British fighter pilots were eating carrots to improve their vision, as a way of explaining the sudden ease with which the Nazi bombers were shot down, even during the night. In fact, this information was only intended to keep a new radar system secret that the English had developed (Smith, 2013).

– *Chemistry revisited*. This sentence is an excellent trigger to study the chemistry of the *cis-trans* isomerization, a key reaction for the vision process (Rando, 1990). It is possible to use molecular models to discuss how the isomerization causes a change of the shape of the molecule.On the other hand, this sentence gives teachers a great opportunity to delved into the concept of solubility, as with vitamin C in the previous sentence, allowing the comparison between the chemical structures of water-soluble vitamins and fat-soluble vitamins, and their expected solubilities in different solvents. A simple experiment to illustrate these properties is the extraction of carotenes from grated carrots using water, ethanol and oil. Under the same conditions, the difference in the intensity of the color of the liquid (orange) indicates that the extraction is much more effective with oil than with ethanol than with water. This is an expected outcome since vitamin A and carotenoids, as isoprenoid derivates, are practically insoluble in polar solvents and readily soluble in non-polar ones.

Sentence #4. *When preparing fried foods, use as little oil as possible in your cooking.*

– *Theoretical foundations*. During the frying process, numerous physicochemical phenomena occur that have consequences on the texture, aroma, taste and color of the final product (Dobarganes, Márquez-Ruiz, & Velasco, 2000). When food comes in contact with oil at a temperature much higher than 100 °C, the water on the surface quickly evaporates. This dehydrated outer surface forms a crunchy crust that, along with the steam that escapes 'pushing' outward, function as barriers that prevent oil from entering the food while cooking (Montes et al., 2016). This means that, if the frying is well done, the absorption of fat is minimized. If the amount of oil used is low, when the food is added, the temperature of the cooking medium will decrease considerably. In this case, instead of quickly achieving a crunchy crust, more oil will enter. The same happens if there is enough oil but it is not at the right temperature (Gamble, Rice, & Selman, 1987): if the temperature is less than 150 °C, excess oil will be absorbed and if it is greater than 200 °C the oil will begin to decompose generating undesirable compounds, such as acrylamides (Montes et al., 2016). Both, the FAO and the WHO, indicate that high consumption of fried foods is a risk factor for health (FAO, 2012).
– *Chemistry revisited*. This sentence could be used as a starting point for the teaching of concepts such as density and the relationship between chemical structure, intermolecular forces and boiling points and alkene's stability and oxidation. Furthermore, it can be used to talk about enzymatic and non-enzymatic browning since lipids can play a role in the latter (Dobarganes, Márquez-Ruiz, & Velasco, 2000).Besides, it opens the possibility to discuss why many chefs double-fried potatoes for more crispness (Wong, 2020). Also, to improve crispness, fresh-cut potatoes can be soaked in cold water before frying to rinse the excess starch that prevents the evaporation of moisture from the potato (Hesser, 1999). How to design suitable experiments can be discussed in the classroom or even performed them with safety precautions.

Sentence #5. *Brown eggs are more nutritious than white eggs.*

- *Theoretical foundations*. The shell of all eggs is mainly made of the same material: calcium carbonate. The difference is that, while white egg shells lack pigmentation, the colored ones acquire different pigments as the egg forms (Lang & Wells, 1987). The production of these pigments is genetically determined and does not depend on the diet of the hen although it can be affected by its age, level of stress or environmental factors (Cherry & Gosler, 2010; Liu & Cheng, 2010; Odabaşi, Miles, Balaban, & Portier, 2007; Roberts, 2004). But, in all cases, the color of the shell of an egg is not related in any way to its nutritional quality. When comparing cholesterol, calorie and protein values, no significant differences are observed in virtually any component with respect to white eggs of the same size (Curtis, Gardner, & Mellor, 1986; Seuss-Baum & Nau, 2011).The fact that, in some countries, brown eggs are more expensive is due to purely cultural and consumer behavior issues (Odabaşi et al., 2007; Lukanov, Genchev, & Pavlov, 2015; Samiullah, Omar, Roberts, & Chousalkar, 2016). Also, long ago, brown egg laying hens tended to be larger and, therefore, consumed more food than white hens (Scott & Silversides, 2000). Although this is no longer the case, the greatest value is maintained by 'tradition'.
- *Chemistry revisited*. This sentence is an excellent trigger to study acid-base reactions since eggshells are primarily made of calcium carbonate. One simple but effective experiment consists of de-shelling an egg by dipping it for a day or two in vinegar: the acetic acid of the vinegar reacts with the calcium carbonate crystals of the eggshell producing carbon dioxide that could be perceived as tiny bubbles nearby.

Sentence #6. *It is convenient to choose cholesterol-free oils to consume.*

- *Theoretical foundations*. Cholesterol is a sterol found in body tissues and transported in the blood plasma of all animals. It is a fundamental part of the cell membranes and plays a key role in regulating their fluidity. It is also a precursor to a large group of substances with important biological activities such as hormones, bile acids and vitamin D (NIH, 2019). For many decades, the Food and Drug Administration (FDA) has been ordering manufacturers of vegetable oil to remove the legend 'Cholesterol free' or '0% cholesterol' from their labels (FDA, 2020). This is a misleading claim since, though there are sterols such as sitosterol in plants, neither contains cholesterol (Behrman & Gopalan, 2005; Nes, 2011). However, until recently, many products in different countries continued to hold the claim and not so many people questioned it. Part of people confusion could possibly be related to the fact that oils contain lipids and cholesterol is a lipid as well.
- *Chemistry revisited*. As a first approach, it could be worth discussing in class what makes a chemical compound a lipid. An analysis of the chemical structures can also be linked to their solubility properties.Also, this sentence opens the possibility to discuss how alkenes' chemical structure and number of unsaturations have a direct influence on their melting and boiling points. Furthermore, it could be used to discuss the relationship between lipidic foods composition and their aggregation state. Triglycerides obtained from animal sources are usually saturated, therefore solids, while those of plant origin are generally unsaturated, therefore liquids at room temperature (Lawson, 1995). Composition and aggregation state of cooking oils can be analyzed and compared to other high lipid content foods, such as butter and margarine. It is also possible to discuss why coconut oil is solid at room temperature given its composition. A simple experiment that can be performed consists of placing for a few hours in the refrigerator different types of cooking oils (olive, canola, corn, etc.) and then comparing their turbidity. Those with a higher percentage of saturated acids will have a "cloudier" appearance (by solidification of some components).A special mention can be made to margarine in order to discuss alkene reactions since inexpensive and abundant vegetable oils are transformed into margarine by partial hydrogenation.

The physicochemical concepts and experiments that can be triggered by each of the sentences are summarized in Table 3.

Besides introducing scientific information, Phase 2 promoted metacognitive reflections about the participants' own learning process. Teachers expressed how far from their prior knowledge were the underlying concepts needed to select the appropriate answer.

Table 3: Physicochemical concepts and experiments that can be triggered by each of the sentences.

Sentence	Physicochemical concepts	Experiments
It is necessary to drink two liters of water per day.	Solvent, solution, solubility, reaction medium	Preparation of effervescent tablets
A natural option to prevent colds is to consume large amounts of vitamin C.	Classification of vitamins Solubility (related to chemical structure) Oxidation and reaction kinetics	Quantification of vitamin C in orange juice
It is essential to eat carrots to ensure good vision.	Chemistry of *cis-trans* isomerization Solubility (related to chemical structure)	Molecular modeling Carotene extraction
When preparing fried foods, use as little oil as possible in your cooking.	Alkene stability, oxidation and browning reactions Vapor pressure Boiling point (related to chemical structure and intermolecular forces) Solubility (related to chemical structure)	Molecular modeling How to improve fried potatoes crispness?
Brown eggs are more nutritious than white eggs.	Acid-base reactions	De-shelling an egg
It is convenient to choose cholesterol-free oils for cooking.	Classification of lipids Physicochemical properties of alkenes and fatty acids (boiling and melting point related to chemical structure and intermolecular forces)	Molecular modeling Composition of cooking oils and their turbidity

Table 4: Percentages of answers for each category (n = 44) after the implementation of the didactic proposal.

	%TD	%QD	%QA	%TA
It is necessary to drink two liters of water per day.	43.2	20.5	36.4	0.0
A natural option to prevent colds is to consume large amounts of vitamin C.	86.4	13.6	0.0	0.0
It is essential to eat carrots to ensure good vision.	95.5	4.5	0.0	0.0
When preparing fried foods, use as little oil as possible in your cooking.	79.5	15.9	4.5	0.0
Brown eggs are more nutritious than white eggs.	100.0	0.0	0.0	0.0
It is convenient to choose cholesterol-free oils for cooking.	100.0	0.0	0.0	0.0

Third specific objective was achieved since teachers were able to assess the importance of understanding and using certain chemical concepts when explaining topic on *human nutrition*.

Finally, during Phase 3, each participant was asked to answer a new printed version of the IS. Results are shown in Table 4.

The comparison of the results on IS before and after the activities is shown in Figure 1.

Table 5: Six categories of teachers' opinions on their assessment of the activities and their potential implementation in high shool classrooms.

Categories	%
(1) I could take this proposal to high school classroom.	79.5
(2) It would allow me to link the curricula topics to everyday situations.	65.9
(3) It would make my class more dynamic.	31.8
(4) It is an innovative proposal.	25.0
(5) It would stimulate the interest of my students.	20.5
(6) It would stimulate the attention of my students.	18.2

At the beginning of the activity, there was a wide disparity of previous opinions and ideas with a strong tendency to consider the sentences as true. After the theoretical discussion, much less scattered responses were observed with a much more critical stance.

Finally, teachers were asked for their written opinion about the activities carried out and their potential implementation in their high school classroom. Their ideas are summarized in the six positive categories of Table 5. The total exceeds 100% because each of the 44 opinions provided data for more than one category.

The majority of teachers considered that this didactic proposal could be carried into the classrooms and would allow daily situations to be linked with contents of the curriculum. Many also considered that it could add dynamism to their classes and stimulate the interest and attention of their students.

Conclusions

In this research, methodology, contents and results from a successful workshop implemented with 44 high school science teachers are presented. Triggering sentences from nutrition topics revealed stereotypical and 'common sense' ideas that are usually found on the media, but which are not based on chemical or biochemical concepts.

The workshop aim was for the teachers to achieve conceptual changes on scientific contents related to nutrition. Design of the workshop according to the SCCL promoted the emergence of participants' cognitive conflicts and the subsequent motivation to achieve further knowledge. A pleasant environment in the classroom predisposed them to enjoy further learning (Keller, 2010; Sanmartí & Marchán, 2015) and proved to be relevant to discuss the importance of reliability concerning information sources.

This proposal effectively allowed teachers to revisit many canonical concepts of chemistry and the possibility to change their traditional way of teaching them. The approach proved to be a successful way to narrow the gap between scientific contents like solubility, density vapor pressure, miscibility, reactivity, isomerization, and biochemical concepts like vitamins, lipids, water content, etc., and the way that they could be taught.

While teacher training is important to provide them with deeper knowledge about chemistry contents involved in everyday life, the question about to what extent this proposal can be implemented in middle school remains open for further investigation.

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