Concept Mapping in Lebanese High Schools to Improve Students' Achievement: a Quasi-experimental Study

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Abstract

Providing knowledge alone is ineffective in initiating and addressing a healthy lifestyle and related social behaviors in education. The aim of this study was conducted to evaluate the effectiveness of the concept map tool on students' achievement in the topic on dietary supplements. A quasi-experimental study was used depending mainly on the pre-test/post-test design where the concept of concept mapping was employed in the setting of a nutrition chapter in a 12th grade biology class in Beirut, Lebanon. Findings showed no difference between both genders in terms of knowledge in dietary supplements. However, mastering acquired knowledge, self-scientific reasoning, and planning appeared to be mediators for the desired students' health achievement in the experimental design. The obtained findings highlight the usefulness of implementing concept maps as a theory-guided health intervention that could contribute to strengthening student knowledge and health promotion in Lebanon.

Keywords: Lebanon, students, knowledge, nutrition, biology, concept map, and achievement

1. Introduction

Educating students about dietary supplements in the Lebanese high school education programs can present a new challenge to the teachers' progress since students are unprepared to grasp and analyze new terms and concepts in topics like dietary supplements and non-vitamin/ non-mineral supplements. Consequently, they would apply their frail cognitive knowledge in parallel to real-life situations. In addition, the presence of many details generates many misconceptions that hinder them from grasping such topics (Amar, 2003). For example, the term "natural" may suggest to consumers, among them seniors, that the supplement is safe, especially when compared with prescription drugs that are known to have side effects. But 'natural' is not necessarily safe. Although many supplements can be used safely by most people, other supplements including some herbal products can be dangerous. For instance, aristolochic acid, found in some traditional Chinese herbal remedies, has been linked to severe kidney disease (Yang et al., 2014). Also, the herb comfrey contains certain alkaloids, that when ingested, may cause serious and even fatal liver damage (Palmer, 2004). In addition, certain supplements can be toxic at high doses, or found to interact with other medications that could cause injury. The main objective of this nutrition topic is to distinguish between different types of dietary supplements and other basic principles which are essential bases for building knowledge used to maintain a healthy life style and behavior.

Few studies have been written on the specific methods and suitable strategies for integrating the topic on dietary supplements into education and training courses for high school students.

Nevertheless, it has been proven that the lack of training tools (in many areas: prevention, emphasizing training sessions on acute health education rather than preventive care, inadequacy of educational resources committed to disease prevention, and the area of lack of reimbursement for nutrition counseling by registered dietitians) may explain the low level of preventive nutrition counseling that can be seen in the daily health life styles and practice settings (Adam et al.,2006). In 2006, a study by Adam et al indicated that most of the information about nutrition continues to be taught in the basic science courses (like biology or life sciences) and not specifically identified with the discipline of nutrition (Adam et al., 2006), as is the case in Lebanon.

1.1 Statement of the Problem & Significance of the Study

Stemming from the interest in consuming healthy foods, claims about the use of dietary supplements have significantly increased in many regions of the world (Camire&Dougherty, 2005). In 2013, Hawkes stated that nutrition education is rarely implemented in schools; he aimed at integrating food and nutritional education in the school's curriculum. Claims about nutrition are not fully addressed in the curricula even though food laws and regulations are tackled in the undergraduate and graduate food science curricula (Camire& Dougherty, 2005).
Similarly, in Lebanon, high school students have several misconceptions about dietary and nutrition supplements, which in turn directly affect their health. Some students face many difficulties in understanding some given biology or nutrition terms leading to the misunderstanding of certain topics. This is especially observed among Lebanese 12th grade "Humanities " students in their biology class. This may be due to the lack of using appropriate learning tools and inadequate time allocated to teach these topics (Hill, 2005).

Therefore, the use of concept map tools in planning, monitoring, and evaluating are essential for adequate and meaningful understanding of the biology and nutrition topics. Moreover, they may enhance students' achievement in different learning stages.

As an intervention, this study targeted adolescents' knowledge about dietary supplements in an effort to increase their knowledge in this area. The concept mapping intervention's primary goal was to incorporate a new educational tool, a concept which is not intensively acquired within the classroom settings, for improving knowledge of students on dietary supplements.

1.2 Research Questions

This study specifically addressed two questions:

1. Does concept mapping reveal a direct impact on students' achievements in the "dietary supplements topic" specifically in the 12th grade "Humanities" sections in Lebanon?
2. Is there any significant difference in the achievements between both genders when using concept maps?

1.3 Objectives and Hypotheses of this Study

The overall objective of this study was sought to evaluate the effectiveness of concept mapping, a theory-based, health intervention tool, in influencing the knowledge level of 12th graders on the topic of dietary supplements. Specifically, the researchers tried **to** determine the changes in the 12th graders in the Humanities section after using concept maps as a tool, in the following 3 domains:

1. dietary supplements' knowledge
2. self-reasoning and planning
3. participation and communication

This study also investigated the difference in students achievements between both genders when using concept maps.

1.4 Hypotheses:

1. Concept map tools reveal a direct impact on students' achievement in the topic of dietary supplements.
2. There are no significant differences in achievements between both genders when using concept maps.

2. Literature Review and Theoretical Background

2.1 Concept Map Definition

Concept mapping can be defined as the tool or technique of visually applying graphical representation of concepts linked with propositions. It usually includes construction of models enclosed in boxes or other shapes and propositions showing relationships among the concepts indicated by arrows and linking words.

This can be designed by hand or using a specific computer software that simplifies the inclusion and conversion of various: colors, shapes, figures, hyperlinks, and audio. Such computer programs support easy manipulation, dynamic linking, publishing, and storage advantages (Canas et al., 2003). Recent studies have shown that designing concept maps on computers are more interesting and easier than manual ones (Chang, Sung & Chen, 2001).

Concept maps are mainly described as "*graphic organizers"* that show relationships among concepts or processes by means of: spatial position, connecting lines, and intersecting figures (Novak &Gowin, 1984). The technique of concept maps is based on Ausubel's assimilation theory of cognitive learning (Ausubel et al., 1978), in which "meaningful learning occurs when new information is integrated into the existing foundation of prior knowledge. This integration requires three main elements: (1) prior knowledge of a topic, (2) meaningful material, and (3) the learners' intent and ability to integrate the new material into their prior knowledge " (Mayer, 1979). Furthermore, Mayer mentioned that the mind organizes information in a hierarchical top-down fashion, which is more efficient than in rote (or memorized) learning where new concepts are added to the learner's framework in an arbitrary and verbatim way, producing a weak and unstable structure that quickly degenerates(Mayer, 2002).

Moreover, concept map techniques can be used not only for summarizing the acquired knowledge, but also for utilizing diverse methods to evaluate learners' performances and diagnosing their misunderstandings (Ruiz-Primo, Schultz &Shavelson, 1997), designing and developing a project about learning materials, making decisions (Coffey, 2007), visualizing information to foster cognitive processing of retrieving knowledge (Tergan, Keller &Burkhard, 2006), supporting problem solving performance (Kinchin, 2000; Okebukola, 1992), assisting navigation, and finally searching for knowledge management in web based learning environments (Canas et al., 2003).

2.2 Concept Map Tools in Education.

Concept Maps are used as an active intervention tool for understanding science concepts and theories (Collette and Chiappetta, 1989). Once teachers introduce a new science topic, their students acquire it through a new cognitive process to build up new meaningful concepts whether consciously or subconsciously. According to Safdar (2010), "If teachers learn how to construct concept maps and use them for planning and assessing lessons, they will be able to teach students better how to make concept maps to organize their thoughts and ideas." Briefly, concept maps can be used for knowledge in: (1) construction, (2) learning, (3) assessment, (4) evaluation, (5) recording of understanding and misconceptions, (6) and instruction (Mintzes, et al.1997 & Mintzes, et al.1998).
Students can use concept maps as a creative tool to help themselves acquire knowledge, construct it in new situations and apply the six levels of Blooms taxonomy. Concept Maps examine the students' prior knowledge in order to determine the starting point of education which is followed by the progression of knowledge throughout a course (Hoz, Bowman &Kozminsky, 2001; Pearsall, Skipper &Mintzes, 1997; Novak &Gowin, 1984; Novak, 1998; Mintzes, Wandersee& Novak, 2000).

In 1984, Novak & Gowin mentioned that concept maps were used as tools that represent schematic representation between students' prior knowledge and recently acquired one. Using concept maps provides guidelines and strategies for the theoretical foundation of nutritional health promotion programs and the translation of theory into actual involvement activities for adoption and implementation among health educators and researchers (Bartholomew et al., 2006).

Concept maps is a meta-learning technique that can be used as a flexible tool for organizing information by identifying the connection between prior knowledge and new ones . General concepts are placed at the top of the map and more specific items are consecutively arranged in a cascade manner. To get a successful educational assessment, epistemologists encourage educators to use three categories for concept maps: maps with open propositions, maps with closed propositions, and maps with semi-open propositions (Alonso & Araya, 2008).

2.3 Concept Maps and Students' Achievement

One of the main goals in education is to develop self-directed learners using specific types of concept map strategies that affect students' learning achievements. A 2010 study done in a high school in Turkey by Yunus Karakuyu, aimed to investigate the impact of concept mapping on 58 ninth-grade school participants related to their physics achievement. Results showed that while there were no significant differences in the attitude and achievement between the experimental and control groups, however it showed that drawing concept maps was more effective than traditional instruction in improving students' physics achievement.

2.4 Concept Maps and Students' Gender

Different studies proved that a significant difference between females and males is presented regarding students' achievement toward science courses, with a high mean score for boys than girls at the middle school years, where both genders show same achievement till grade 10 of the school years. Then a great successful shift starts to appear for boys through the consecutive school levels (Catsambis, 1995; Baker & Leary, 1995; Jovanic& King, 1998; Lightbody&Durndell, 1996; Simpson & Oliver, 1990; Sullins, Hernandez, Fuller &Tashiro, 1995; Campbell, Voekl& Donohue, 1998). One can notice that genders' achievement has been used as one of the essential factors affecting science learning in a skillful way. In general, many researches revealed that boys achieved better than girls in sciences, but secondary school boys had a more positive attitude toward chemistry than girls (Jonassen, 1996).

3. Methodology

3.1 Concept Map Tool as an Intervention

The concepts maps were designed based on the information needed to be acquired on dietary supplements and as intervention to aid students in grasping the material. The protocol followed the six successive steps adapted from Bartholomew et al., 2006. Specific tasks were utilized within each step that guided the decision making process.

Step 1: Conducting a Needs' Assessment
Step 2: Building Up Concept Map Objective
Step 4: Developing a Concept Map Program
Step 5: Taking Up and Implementation
Step 6: Building up an Evaluation Plan

3.2 Participants

This study was conducted on 60 students enrolled in Grade 12 humanities section at a public high school in Beirut. The students were assigned randomly without replacement: experimental group used concept map tools and a control group used tradition education sessions as a study skill (n = 30 with equal number of both genders for each group). Students' mean age was 17.5 ranging from 17 to 18 years.

3.3 Research Design

A quasi-experimental study was designed to examine the effects of the concept mapping on students' achievements in comparison to an active control group. The intervention group received a one-day training program whereas the active control group received dietary supplements' educational lessons in 2.5 hours. This intervention took place on a weekend and started with a brief overview about dietary supplements' information based on dietary supplements guidelines (MOPH, 2006) presented by a trained lecturer in the field of nutrition coming from a vocational college. After subjecting them to the 2.5 hours introduction, the program for the active control group was completed. The experimental group then received a psychological program that is based on the Health Action Process Approach (Schwarzer, 2008) which addressed self-efficacy and strategic plans. Two kinds of plan skills were practiced: acquired knowledge action plan and scientific reasoning coping plan. Participants received and prepared action plan sheets, and they were asked to generate a detailed plan about how, where, and when they intend to consume dietary supplements. Types of dietary supplements were urged to be discussed among participants because there are various kinds of dietary supplements. Moreover, they received and prepared coping plan sheets that required them to imagine situations where barriers might emerge that would prevent them from acting as previously planned. In discussion groups, students shared their experiences with intentions and barriers, and they learned how to recover from setbacks. Nutrition calendars were introduced to help them practice how to make a weekly plan and a general nutrition planner. Handouts to assist future planning were also provided so that participants could generate action plans (such as to plan which dietary supplement to take, how, where, when, and with which amount) and coping plans (such as to anticipate possible barriers, to find coping strategies, and to get back on track after being derailed

Moreover, this study was sought to asses if there was a difference in students' achievement between the two genders and the essential need for future nutrition-educational intervention among high school students.

3.4 Data Collection and Analysis.

In this experimental design, data collection proceeded as follows:

- Baseline pre-test (T1) collection for both groups were assessed to determine prior knowledge before applying concept mapping as a tool of educational intervention.
- In the first week and sixth week after the intervention, the post-tests (T2) were collected to identify any potential changes in the students' knowledge about the dietary supplements after the intervention.

The data was analyzed using the SPSS statistic software version 17. Descriptive statistics were employed as general analytic procedures to describe the demographic profile of participants and research variables. Repeated Measure ANOVA were used to identify group x time interaction effects. Independent t-test was performed to compare mean score of tested variables between intervention group and the control one. Paired sample t-test was applied to compare the mean score of tested variables in both studied groups.

4. Results and Findings

4.1 Hypothesis 1 and Question 1 (with respect to the three domains)

- *Mastering acquired knowledge (A):* The experimental group indicated significant increase in the achievement of dietary supplement knowledge in this domain from baseline (T1) to posttest (T2) six weeks after the intervention where p=0.000 and the percentage of variation was 180.06% .

The intervention group indicated a higher percentage of variation in mastering knowledge about dietary supplements topic than those of the control one from baseline to posttest taking six weeks of intervention.

- *Practicing scientific reasoning (B):* A similar pattern of results was found for dietary supplements self-reasoning with significant differences between the intervention and the active control groups. The concept map group indicated significant increase in dietary supplements self-reasoning from baseline to posttest six weeks after the intervention where p=0.000 and the percentage of variation was 57.96%.
At six weeks after intervention, the active experimental group shows a greater significant increase. This showed that knowledge together with enhancing self-reasoning belief and planning intervention maintained continuous improvement in the desired behavior.

- *Mastering communication techniques (D):* The experimental group indicated an increase in using communicative skills concerning this domain from baseline to posttest, six weeks after the intervention where p=0.001 and the percentage of variation was 45.05%;this was caused by the provision of the mastering communicative technique enhancement session. For the active control group, it showed higher increase in improving domain (D) at all-time points where p=0.025 and the percentage of variation was 45.33%.
So when comparing these two groups, a significant difference was noted in all the three domains where the dependent variables are: mastering acquired knowledge, practicing scientific reasoning, and mastering communicative technique. This effect increases the social-cognitive predictors of dietary behaviors namely presented in table 1.

Based on the results discussed above, the first hypothesis was accepted; and to answer the first question, this study showed that concept maps do reveal a direct impact on students' achievement in "dietary supplements" topic.

4.2 Hypothesis 2 and Question 2

When comparing data analysis of the participants' genders and their effective achievement in dietary supplements' where concept maps were used for grade 12 school students, both experimental and control groups indicated increase in the achievement of dietary supplements' knowledge concerning (A) and (B) domains from baseline to posttest, six weeks after the intervention (table 2).

For the control group:

Concerning Domain (A) the significance between the two genders was 0.695 in pretest, and it decreased to 0.094 in posttest. Concerning Domain (B) the significance between the two genders was 0.260 in pretest and decreased to 0.329 in posttest. Concerning Domain (D) the significance between the two genders was 0.939 in pretest and decreased to 0.164 in posttest. The decrease in p- value between pre-test and post-test can be related to the reason that the students had a prior poor knowledge about dietary supplements.

For the experimental group:

Concerning Domain (A) the significance between the two genders was 0.302 in pretest which decreased to 0.287 in posttest.

Concerning Domain (B) the significance between the two genders was 0.247 in pretest and it decreased to 0.354 in posttest. Concerning Domain (D) the significance between the two genders was 0.698 in pretest it decreases to 0.439 in posttest. The decrease in p- value between pre-test and post-test can be related to the reason that the students had a prior poor knowledge about dietary supplements. Also, as shown in the tables 3 and 4, there is no significant difference between genders' achievement in the same studied groups and between T1 and T2.
Based on the following results, hypothesis 2 was also accepted and thus, there were no significant differences in achievements between both genders when using concept maps.

5. Discussion and Conclusion for Application of Research Findings

Based on the outcomes of this study, the researchers concluded the positive effect of concept maps as a health-intervention tool to improve the retention of scientific knowledge and reasoning and promote the adequate use of dietary supplements especially among high school students. This tool and intervention can be applied in biology courses as an educational tool and especially for nutrition-health education. This type of intervention is applicable in the school and university curricula. Recently, general health education curricula have been developing to maintain a healthy lifestyle in some Lebanese high schools striving to meet the general educational goal that helps students succeed and develop their applicable health knowledge. This study is important, not only to provide students with effective knowledge to reach health awareness, but also to encourage them to use the most favorable instruments to satisfy their main aim.

Moreover, the findings of this study are in parallel with others that have shown concept maps to be successfully employed as a practical approach for acquiring knowledge and changing health behavior. This tool is a relatively new technique in research studies, but it is used frequently in education to extract prior knowledge and to assess learning over time (Daley, Shaw, Balistrier, Glasenapp & Piacentine., 1999). Concept mapping permits the optimal understanding and more effective use of knowledge. The nature of the activity itself requires "mappers" to make connections between concepts where they see it fits (De Simone, 2007). Making links between these connectors is particularly important in understanding how the social determinants of health exert their influence and effects on students' behavior indirectly (Baum, Begin, Houweling & Taylor, 2009). The findings of this current study can be replicated in the context of health behaviors. The model appears to be appropriate to participants using theory-based intervention methods.

Even though this study concluded encouraging outcomes in developing nutritional knowledge in an effective manner among school students, it is not only time consuming in Lebanon , but also involves extra expenses (for training facilities, documents, trainers, and data collectors). Thus, might be considered as a challenge for to make a behavioral change and apply a new health theory-based intervention in 'traditionally oriented' higher education institutions.

6. Recommendations

The concept maps' package covers mainly three domains: mastering acquired knowledge, practicing scientific reasoning, and mastering communication techniques. The effects of these three domains cannot be disentangled, and one cannot judge whether one of them would have been sufficient to achieve the present results. To identify the specific effects of each of these ingredients, one could design a randomized controlled trial with more experimental groups, providing each group with one and only one component.

7. Limitations of the Study

This kind of research would have covered more high school classes ,both private and public, but because of time and cost constraints, a small sample was used. Further, concerning grade-12 students who choose to participate in health related experimental group discussions and interventions are likely different from students who are not interested to participate in such programs. Therefore, more research is needed to assess whether the results could be generalized to a more diverse group of school students or any other groups.

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Table 1: Comparison between Pre and Post Tests in the Three Domains for Both Groups

	Means		Sig	% of variation
	Pre	Post		
A (4 pts)	1.37	2.42	0.000	76.83%
B (13 pts)	5.30	7.59	0.000	43.27%
D (3 pts)	1.25	1.82	0.025	45.33%
Total (20 pts)	7.92	11.74	0.000	48.34%

	Means		Sig	% of variation
	Pre	Post		
A (4 pts)	1.14	3.18	0.000	180.06%
B (13 pts)	5.57	8.79	0.000	57.96%
D (3 pts)	1.52	2.20	0.001	45.05%
Total (20 pts)	8.21	14.16	0.000	72.40%

Table 2: Effect of Gender on the three domains for both Groups

	Pretest			Posttest		
	Male	**Female**	**Sig**	**Male**	**Female**	**Sig**
A (4 pts)	**1.40**	**1.33**	**0.695**	**2.63**	**2.20**	**0.094**
B (13 pts)	**4.93**	**5.67**	**0.260**	**7.33**	**7.85**	**0.329**
D (3 pts)	**1.23**	**1.27**	**0.939**	**1.60**	**2.03**	**0.164**
Total (20 pts)	**7.57**	**8.27**	**0.385**	**11.43**	**12.05**	**0.474**
	Pretest			**Posttest**		
	Male	**Female**	**Sig**	**Male**	**Female**	**Sig**
A (4 pts)	**1.04**	**1.23**	**0.302**	**3.03**	**3.33**	**0.287**
B (13 pts)	**5.13**	**6.00**	**0.247**	**8.43**	**9.15**	**0.354**
D (3 pts)	**1.60**	**1.43**	**0.698**	**2.33**	**2.07**	**0.439**
Total (20 pts)	**7.76**	**8.67**	**0.366**	**13.77**	**14.55**	**0.523**

Table 3: Comparison for Means, Significance (Sig), and % of Variation of Knowledge about Dietary Supplements in Both Groups

	T1				T2			
Variable / Group	**M Pre**	**Post**	**Sig**	**%of variation**	**Pre**	**M Post**	**Sig**	**%of variation**
A (4 pts)	1.37	2.42	0.000	76.83%	1.14	3.18	0.000	180.06%
B (13 pts)	5.30	7.59	0.000	43.27%	5.57	8.79	0.000	57.96%
D (3 pts)	1.25	1.82	0.025	45.33%	1.52	2.20	0.001	45.05%
Total (20 pts)	7.92	11.74	0.000	48.34%	8.21	14.16	0.000	72.40%

Table 4: Means and Significance (Sig) of Knowledge about Dietary Supplements in Both Genders of the Studied Groups

T1	**Pretest**			**Posttest**		
	Male	**Female**	**Sig**	**Male**	**Female**	**Sig**
A (4 pts)	1.40	1.33	0.695	2.63	2.20	0.094
B (13 pts)	4.93	5.67	0.260	7.33	7.85	0.329
D (3 pts)	1.23	1.27	0.939	1.60	2.03	0.164
Total (20 pts)	7.57	8.27	0.385	11.43	12.05	0.474
T2						
A (4 pts)	1.04	1.23	0.302	3.03	3.33	0.287
B (13 pts)	5.13	6.00	0.247	8.43	9.15	0.354
D (3 pts)	1.60	1.43	0.698	2.33	2.07	0.439
Total (20 pts)	7.76	8.67	0.366	13.77	14.55	0.523