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Lebanese Biology Teachers Perceptions and Practice of Conceptual Integration

Hanadi CHATILA
Lebanese University

Abstract: This paper investigates Lebanese high school biology teachers' perceptions and practice of Conceptual Integration among different science subject areas in the biology class. Fifty Lebanese in-service high school teachers completed a questionnaire about their perceptions of conceptual integration. Then, ten of them participated in a focus group to discuss the implementation of Conceptual Integration through an activity presented in the grade 10 biology program. The findings show that although teachers acknowledge the importance of integrating physics and chemistry in their biology teaching, they avoid implementing Conceptual Integration. In addition, they lack the right knowledge about what Conceptual Integration is and how to approach it in their practice. The study shed the light on the urge to revisit the teacher education program at the Faculty of Education at the Lebanese University, at the pedagogical level to include Conceptual Integration as a main strategy to teach Sciences and at the content knowledge level to highlight the one paradigm of science that includes various science disciplines sharing the same features of the "nature of Science".

Keywords: Conceptual integration, Biology education, Teacher education

Introduction

Shulman (1987) highlighted seven basics categories for teaching knowledge that include: subject matter knowledge (SMK), pedagogical content knowledge (PCK), curricular knowledge, general pedagogical knowledge, knowledge of the learners and their characteristics, knowledge of educational contexts and knowledge of educational purposes. In science education, subject matter knowledge is defined as the knowledge of both specific topics of the curriculum and the epistemology of science and the nature of scientific knowledge (Mizzi, 2013).

In this context, Lederman (2013) stated that science is a paradigm and scientists should perceive science as a complete body of knowledge. Thus, there is integration among the different scientific subject areas since they share the same epistemology and nature of knowledge, and, therefore, the integration of those different areas in the teaching and learning of any related discipline is a must for meaningful learning.

In the constructivist approach, students interpret the new knowledge according to what they already know, and the nature and the level of the new knowledge integration depends on their existing knowledge. So, meaningful learning can effectively build their knowledge structures (Ausubel, 2012; Tuysuz, Bektas, Geban, Ozturk& Yalvac, 2016) to reach a conceptual integration among different disciplines involved in their learning (DiSessa, 1993; Matthews, 1993).

Theoretical Framework and Literature Review

Conceptual Integration

Conceptual Integration proposed by Fauconnier and Turner (2002) can be defined as the learners' capability to use their pre-requisite knowledge or concepts in a certain science subject whilst they are learning a concept or topic in another science subject (Taber, 2008). It offers insight into our way of thinking, creating and understanding the world around us (Fauconnier & Turner, 2002). Taber (2005) considers Conceptual Integration as the learner knowledge structures which are organized to allow connections between different areas.

Conceptual Integration has become an area of interest in science education. Research studies have highlighted its importance since it is necessary for meaningful learning (Taber, 2005; 2008) and for overcoming misconceptions (Ganaras, Duman & Larcher, 2008).

In science teaching and learning, Conceptual Integration can be achieved among different areas of science only when learners have the adequate prior knowledge and the learning process that promote meaningful learning (DiSessa, 1993; Matthews, 1993; Taber, 2005). In addition, Conceptual Integration is believed to be important and necessary for the development of scientific literacy in science learning (Lederman, 2013; Tuysuz et al., 2016).

In this context, Conceptual Integration can be considered as the method employed by scientists. Science is expected to produce a large coherent and internal consistent body of knowledge distributed over different subject areas that may be represented by a single framework. Therefore, when scientists face a problem, they investigate the whole scientific paradigm rather than examine only one area or one discipline in order to reach and generate their conclusions (Chalmers, 1999; Lederman, 2013).

Moreover, the nature of scientific knowledge that involves an ongoing empirical research producing contradictory results to the general paradigm should not affect that coherence and internal consistency because any anomaly should be investigated and explained (Taber, 2005; 2008).

In his turn, Novak (2011) considered Conceptual Integration as essential for meaningful conceptual understanding in science. Since all scientific concepts are interrelated, topics should not be taught separately. Thus, we cannot think about each concept separately, and therefore an integrated science curriculum has become necessary to meaningful efficient learning.

Research studies around the world have identified limited connections among content elements in both students' knowledge and curricula. Accordingly, multiple countries have reformed their science curricula and sought the implementation of curriculum integration, e.g. Next Generation Science Standards NGSS (2013) reform, in an attempt to achieve meaningful learning to include disciplinary core concepts and interdisciplinary ones as a means to establish connections among science contents. The principal goal is to enable students to develop a well-connected science understanding (Opitz, Neumann, Bernholt, & Harms, 2017).

Conceptual Integration affects not only the conceptual understanding of scientific concepts but also the learners' epistemic and epistemological beliefs. Learning is not separated from the learners' beliefs about the nature of knowledge. In fact, in a given learning situation students tend to anticipate through their epistemic beliefs the "what" to be learned and the "how" to deal with that learning situation (Bromme, Piesch & Stahl, 2010). The epistemological beliefs in science refer to the learners' understanding of a concept or theory, to how it is built up, including their knowledge about the process of knowing about scientific knowledge. So, those beliefs may affect the learners' scientific skills development such as decision making and problem-solving (Hofer, 2001).

As the Conceptual Integration involves combining different topics areas or disciplines, it helps students act like scientists. For example, when teachers teach a certain advanced concept in biology, they should use more basics ideas and fundamental concepts taken in biology, physics or chemistry topics to reach a more meaningful learning.

The literature on science education has mainly focused on teaching strategies and students' conceptual understanding of a content area; however, little research has investigated Conceptual Integration, especially for middle and high school science teaching and learning (Tuysuz et al., 2016). Research studies on Conceptual Integration research studies are mainly directed towards the understanding of concepts at college and university levels, and these studies often deal with specific Physics and chemistry concepts.

The Lebanese Curriculum

In the Lebanese schooling system, biology is taught separately from other science disciplines (chemistry and physics) at both the intermediate and secondary levels. It is taught under the name of Earth and Life Sciences from grade seven up to grade nine, and in the secondary level it is taught differently across grades under the titles of “Life Sciences” to Life Science Baccalaureate students and “Scientific Literacy” to Socio-Economic Baccalaureate students.

Although the Lebanese curriculum (1997) is not a competence-based curriculum ,it highlights the integration among different disciplines in its general and specific objectives.

The Lebanese Science curriculum is rich in content, details and concepts with a great emphasis on knowledge and skills. Students should learn through exploring, investigating and describing their experiences in order to achieve meaningful learning (Chatila & Al Husseiny, 2017).

Through their objectives, the Lebanese Biology curricula (1997) enable students to explore the integration of disciplines. For example, one of the objectives the Life and Earth Sciences curriculum is to “Permit the students to identify integrated domains within different disciplines and be able to transfer them to different fields.”

Research Problem

Being a science educator investigating both the pre and in-service teacher development programs of biology teachers at the Faculty of Education at the Lebanese University, the researcher has noticed that Conceptual Integration in Biology is not well approached by biology teachers.

A thorough review of the literature shows that Conceptual Integration has not been investigated in the general Lebanese educational school system, especially in Science and Biology.

The current study investigates Biology teachers’ perceptions and practice of Conceptual Integration in biology classes and addresses the following questions:

1- What are the in-service Lebanese biology teachers’ views about the conceptual integration of biology and physics and/or chemistry?
2- Do biology teachers promote Conceptual Integration in their teaching?
3- What are the barriers to Conceptual Integration?

Method

The study consists of two main parts: The first part of the study is designed to investigate Lebanese biology teachers’ perceptions of Conceptual Integration. An open-ended questionnaire was administered to 50 Lebanese high school in-service biology teachers who have at least two years of teaching experience in order to investigate their views about Conceptual Integration. The questionnaire includes five questions:

1- Do you integrate physics/chemistry concepts in your teaching?
    - If yes, explain how and give an example.
    - If not, explain why you don’t.
2- Do you have any difficulties in teaching about topics where the conceptual integration can be realized? If yes, state those difficulties.
3- Do you use different instructional strategies/methods while teaching about topics where Conceptual Integration is required?
4- Do you cooperate with physics/chemistry teachers when needed? If yes, explain how.
5- Do you investigate the conceptual integration while preparing your lesson by
    i- checking the curriculum to find out the level of integration?
    ii- asking physics/chemistry teachers?

In the second part of the study the researcher further investigates the teachers’ perceptions and their practice of Conceptual Integration in Biology in a focus group in which ten Lebanese Grade Ten biology in-service teachers explain a biology concept.

A focus group discussion is a qualitative approach technique where a group of individuals discuss a specific topic, concept or idea in order to gain a thorough and deep understanding of issue in question (O.nyumba, Wilson, Derrick & Mukherjee, 2018).

The researcher selected the biology concept of "transport and upward movement of crude sap in plant" as an example in the focus group discussion. The concept, which is presented in the Grade Ten Life Sciences national textbook in the second chapter as 'Activity 2' (p36-37), was selected as one of the concepts that requires integration of a physics fundamental concept.

The focus group aimed to discuss the following questions with the teachers:

1- How would they explain Activity 2 in order to know how they
    - i- perceive the word "pressure"
    - ii- connect physics and biology?

2- Does the activity present all the required information for a meaningful understanding of the concept.

The ten participants were selected from the sample of teachers who had participated in the first part of the study based on their motivation and availability. They teach Biology in English, have a minimum of five years of teaching experience, and hold a Bachelor's Degree in Biology from the Faculty of Sciences as well as a Master's Degree in Science Education-Teaching Biology from the Faculty of Education from the Lebanese University. Data was collected and analysed to answer the research questions.

Crude Sap Transportation

Crude sap is a mixture of water and dissolved minerals that is absorbed by the root and moves upwards through the xylem of the plant. The conduction of crude sap upward the plant via the xylem is subject to root pressure caused by osmosis, transpiration and physical forces, namely cohesion and adhesion forces.

Root pressure

It is the result of osmosis. (Water enters the plant through its root by osmosis. It is the passage of water from the low salt concentration medium to the high salt concentration medium through the cell membrane to make the salt concentration equal). Since the root is higher in salt concentration than the salt, water flows from the soil to the roots, knowing that the root does not allow the passive movement of the salt across the root cell membrane. However, it does allow water, minerals and small organic compounds to pass from the soil to the plant passively. And when the salt concentration inside the root becomes too low, the cell membrane actively transports salts into the root.

Transpiration

It takes place when the plant loses water through the leaf surface primarily from the stomata, or pores in the surface of the leaf used for respiration and photosynthesis. Warm weather and the wind increase the transpiration rate, and consequently the plant draws more water from the roots, which, in turn, take up more water from the soil.

However, the transpiration rate decreases with humidity since evaporation occurs more slowly, which decreases water absorption from the root.

Cohesion and Adhesion forces

Those forces are known as capillary action. They involve the diameter of the xylem and the chemical properties of water. Cohesion force is caused by the hydrogen bond between the molecules of water, as they have a strong attraction to each other causing the molecules to stick together. Cohesion force occurs when the molecules of water adhere to the surface of the xylem.

As the plant transpires, it draws water up through the xylem. Every time a water molecule evaporates, another water molecule is pulled up through the xylem. Through the effect of the adhesion force between the water molecule and the side of the xylem, water molecules overcome the force of gravitation and move up instead of falling back down through a process called capillary action. Therefore, both cohesion and adhesion forces create such a strong attraction that capillary action pushes water to the top end of the tallest trees.

It obvious that the biological concept of crude sap transportation requires the conceptual integration of both the physical concept of pressure and the chemical concept of cohesion and adhesion forces (Plant – Absorption, Conduction, Rise of Cell Sap & Transportation, 2015).

Crude Sap Transportation in the Lebanese Grade Ten Life Sciences textbook

The concept of crude sap transport and movement is presented in grade ten Life Sciences national textbook in the second chapter as 'Activity 2' (p36-37).

The introduction of the activity, as shown in figure 1, proposes two questions about the crude sap transportation: "How can you prove this transportation?" and "what are the mechanisms that permit the moving sap to ascend?

In this study the researcher is interested in the second question where the conceptual integration is identified. The mechanism of the upward movement of the crude sap is presented in "Doc. e", "Doc. f" and "Doc. g" found on page 37, as shown in figure 2.

By analysing the two documents presented in figures 1 and 2, we notice that:

1- "Doc. e" and "Doc. f" present evidence of root pressure without explaining where this pressure is coming from. There is no mentioning of "osmosis", which causes the accumulation of water in the root, in turn, causing the pressure.
2- "Doc. g" discusses the capillarity action and relates absorption to transpiration. However, the textbook only mentions "cohesion forces", denying the presence of "adhesion forces", knowing that capillarity action requires both forces to allow the upward movement of water.

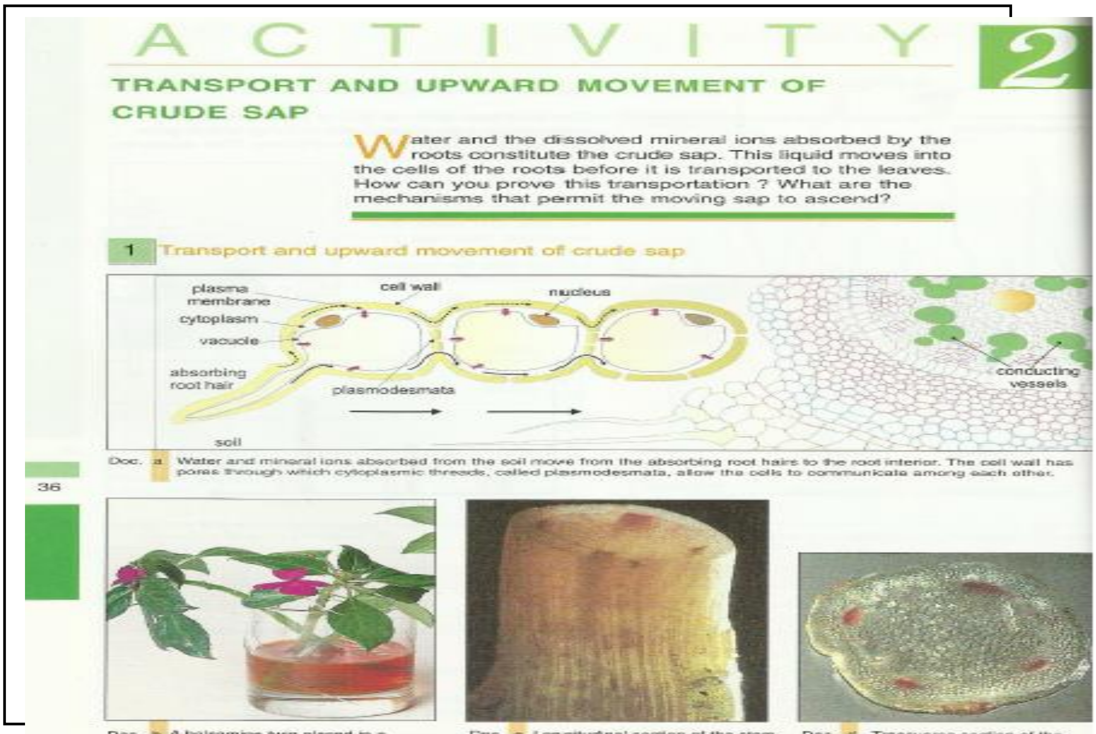

Figure 1.Activity 2, page 36. Life and Earth Sciences, Basic Education, 10th grade, National Textbook (1998)

Therefore, the activity presented in the textbook is descriptive in nature, does not target the cause of the mechanisms and is missing some major information. However, in order to understand the concept of crude sap ascendant movement, the student must have a sound understanding about

- root pressure origin, which originates from the transportation of water from the soil to root due to difference of concentration and to the semi-permeable nature of the root cell membrane.
- capillarity action, including the origin and function of cohesion and adhesion forces.
- Transpiration

Therefore, in order to be able to apply Conceptual Integration, students must know about "osmosis" from Biology and "pressure" and "Capillarity: Cohesion and Adhesion forces" from Physics.

By referring to the Biology and Physics Lebanese curricula, the researcher has found that the two concepts of “osmosis” and “capillarity: adhesion and cohesion forces” are not present in the high school science curriculum. So, they do not represent pre-requisite knowledge for students. Only the concept of “pressure” is present in the grade 9 physics program and represents prior knowledge for grade 10 students.

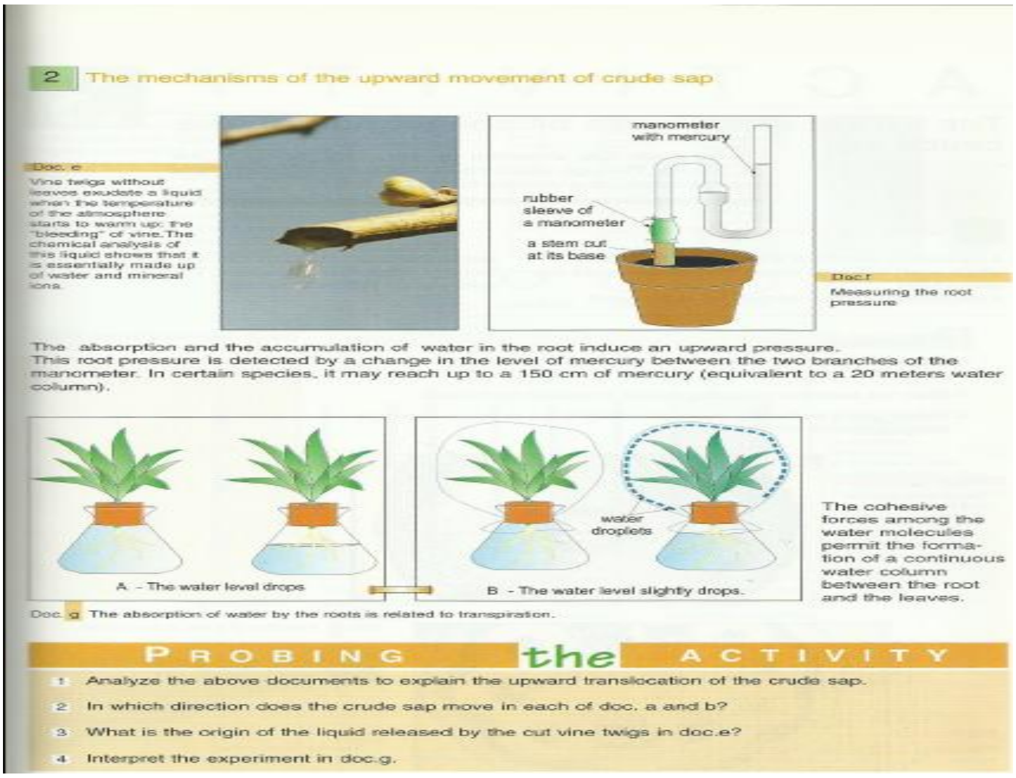

Figure 2. Activity 2, page 37. *Life and Earth Sciences*, Basic Education, 10^{th} grade, National textbook (1998)

Results and Discussion

Questionnaire

Regarding the first question about integrating physics and chemistry in biology, all participants responded that they do integrate other science topics in their teaching, and that they provide many examples from the Lebanese Biology curriculum. For instance, electricity is integrated in the nervous system and organic chemistry in photosynthesis.

The second question addresses the difficulties the teachers face in integrating concepts from physics or chemistry. Only 16 out of 50 participants (32%) stated that they have some difficulties. According to their answers those difficulties may be caused by:

- The curriculum: The absence of pre-requisite knowledge that is mainly due to the curriculum. Many concepts required for integration are barely, if ever, taught, with makes it difficult for biology teachers to integrate them in their teaching. Some teachers’ responses follow below:

  “Sometimes physics and chemistry concepts are not known by students.”
  “Weak pre-exquisite form difficulties in instructing topics.”
  “The complete absence of knowledge about the integrated concept in the curriculum, and the lack of this concept across other subjects.”
  “Usually students not having the needed pre-requisite or being unable to understand the physics or chemistry ideas for lacking basic information or not really understanding those subjects.”
  “Student pre-requisite is approximatively null or weak in physics concepts mainly those integrated in neurology.”

"Maybe when the concept isn't yet explained by the chemistry or physics teacher. Therefore, it will consume more time to explain it. Also, we might need more teaching strategies to make it easier and simpler."

- Students' misconceptions: Participating teachers reported that students usually have many misconceptions regarding physics and chemistry concepts. Those misconceptions are often due to the nature of the abstract concepts and the teaching strategies used by physics and chemistry teachers, which only renders integration difficult and requires the biology teacher to explain the related concepts to ensure that integration is well achieved.
  "Students misconceptions and their forgetting of main concepts."
  "Sometimes I face problems with students because they have misconceptions in many concepts."
- Another factor that, according to the teachers, may lead to difficulty in applying conceptual integration is students' attitudes towards science in general, and their perceptions about science topic areas. One teacher stated
  "Because some students are not involved or interested in biology"
  These teachers highlight the idea that students perceive science as separate disciplines, and that students can't connect between them. This factor may be due to the curriculum that lacks the main part of epistemology and nature of science.
  In addition, the participating teachers mentioned that students sometimes have negative attitudes towards physics and chemistry, which makes it hard for them to work on Conceptual Integration.
  "Students often think that chemistry and physics, as physical sciences, are largely independent from biology, a life science. So, they tend to be not concerned in the topic where conceptual integration is made. Some students are not interested in physics or chemistry which make them feel frustrated."

Concerning the instructional strategies that teachers may use during conceptual integration, only 11 out of 50 (22%) participant stated that they did change their teaching strategies and methods for the purpose of integration, while the majority (78%) made some modifications to their strategies in order to encourage and enhance students' conceptual integration. All of the teachers stressed active learning strategies and methods such as cooperative learning and discussions which help students use their prerequisite knowledge.

"Mainly by asking students to predict outcomes using their acquired knowledge from physics or chemistry. Trying not to give them the direct answer but to encourage them to use their minds through class discussion so that they remember concepts and link them with the topic we are dealing with. Sometimes I pose a problem for them and ask them to do a research using their pre-requisite knowledge in chemistry or physics. In this case they can use internet websites or their books as a reference or ask their chemistry and physics teachers."
"When topics can be integrated I usually starts with brainstorming to use the students' prerequisites."
"I use different instructional strategies like brainstorming in order to detect students' misconceptions and understanding."

Some teachers go further and use resources from the integrated topic areas. One teacher stated, for example using images or even visit the lab
"I use images from other subjects that help to clear the idea I want to explain."
"Sometimes it requires to visit chemistry or physics lab. To discuss a certain objective."

When asked in the fifth question about their collaboration with physics and chemistry teachers when needed, more than half (56%) of the participants responded that they don't cooperate. They argued that they don't need to ask the other teachers, and when they need extra information about a certain topic, they do their own research.

" I usually depend on internet search."
"Usually I google such cases."
"I refer to references and internet to elaborate my knowledge of the integrated topics."

However, 44 % of the teachers stated that they do cooperate with their peers, mainly to check what students know about the integrated topics, or to ask them to explain a certain concept required for integration.

"Sometimes, I ask the teacher to explain the concept before I would reach the required topic, or I ask if the concept is explained yet."
"To check if they took food (lipids, carbohydrates, proteins) in organic chemistry or to check if they took potential difference in physics."

Some teachers reported that they seek help to understand the integrated concept, or to ask for the right strategy in order to address it in the biology class and to better know the level of integration.

"Mainly if I have no idea or little information about concepts."
"In the time of lesson plan preparation, when I face any concept that is related to physics or chemistry, I tend to communicate with my peers in school by calling them or taking an appointment at break times. During the meeting, I try to clearly understand the chemistry or physics concept (to be integrated in my biology lesson) in order not to face any problem during the lesson and to maintain a standard teaching pattern and thus does not let the class deviate from the topic. This would help me to be better equipped in answering questions asked by the students during the period."
"I ask the teacher if this concept was treated, and sometimes I ask more information to make sure about them."
"I ask the teachers some questions that can help me."

Many Teachers also highlighted the conceptual integration and their cooperation with their peers in science projects:

"I cooperate with chemistry or physics teachers when I asked students to do a project related to common topics like pollution."
"Such cooperation is necessary during science fair."

Regarding whether teachers investigate conceptual integration during their preparation, 86% of the participants stated that they do. The majority of the participating teachers (around 81%) explained that they check the curriculum, while the rest choose to ask their peer physics or chemistry teachers.

Focus Group

In response to the first question on how they explain the upward movement of crude sap, nine out of ten participants stated that they follow the textbook and the teacher's guide instructions and ask students to answer the questions presented in "probing the activity" section without adding any extra information for their students.

"I follow the textbook, and don't use any other document."
"for our students in grade ten, the information in the textbook is enough for them."

Only one teacher stated that he/she provides their students with extra handouts from another resource because he/she thinks that the textbook does not provide enough information.

"The activity present in the textbook is not enough… it lacks information about adhesion force. I use other resources when teaching this concept."

As for the question related to "how they perceive the word "pressure," all the participants agreed that "Doc. f" provides evidence for the presence of pressure and that is what the students need to know at this stage. They don't go further in their explanation. They don't recall any information about pressure from physics, and students are always satisfied with the information provided in the textbook.

"for root pressure, the textbook includes an activity that show evidence about this pressure, but we do not explain how this pressure come".
"I don't recall the definition of pressure from physics, the concept is simple and well known by students".

When asked about the mechanism that causes root pressure, only four teachers talked about "osmosis", whereas the rest hesitated about the process. One teacher stated
"I forgot those info. because I don't teach them. I learned about root pressure at university and that was more than ten years ago".

Six of the participants stressed that students don't have to know the origin of "root pressure"; what is required is the presence of that pressure only. However, the other four were hesitant about that and considered that the curriculum is not clear about this point.

"if my students ask about extra information, I ask them to research it and that will be outside the required info."

When asked about "cohesion force" mentioned in "Doc. g", all the participants agreed that students don't have any prior knowledge about that type of force, and that they explain it briefly as mentioned in the textbook without going into details. They argued that cohesion force is a physics concept that they don't have to explain in detail, reiterating that what is present in the textbook is enough for the students to know.

"I am a biology teacher, it is not my job to teach about forces, beside I don't know how to teach it correctly… that is why I prefer to give the definition present in the textbook".
"*there is no time to teach extra concept". "we don't have to make things complicated to our students".*

With respect to the teaching strategies they use, all the teachers stated that they follow the same strategies they usually adopt in their class, by mainly using PowerPoint presentations and the textbook.

Regarding the connection between biology and physics, the participants agreed that the concept in this activity includes physical concepts of pressure and forces. They, however, stated that they neither take this into account during their preparation nor do they cooperate with the physics teachers.

Discussion

The findings clearly show that Lebanese biology teachers who participated in the study face difficulties in approaching conceptual integration in the classroom. Both results of the focus group and the open-ended questionnaire highlight those barriers.

In fact, teachers are not familiar with the concept of Conceptual Integration, and they always perceive the integration from the teacher and content rather than from the student's perspective. They all agree on the necessity of the integration in the open-ended questionnaire, but when asked about the HOW of the integration, it comes as thematic integration implemented by the teacher and considered very superficial, rather than the integration that tackles the prior knowledge of the students and enhance the mobilization of the knowledge to create a new schema in their minds.

Knowing that the Lebanese curriculum is a disciplinary non-integrated curriculum, students don't always have the required prerequisites to practice conceptual integration, and teachers are not aware of how to integrate the required concepts and to what level. This is confirmed by research studies about the importance of the integrated curriculum in producing meaningful learning and in enabling students to connect among different content areas (Opitz et al., 2017).

In addition, a barrier highlighted by the participants is their own content knowledge. They clearly state that sometimes they lack basic understanding about the integrated topics and that they hesitate to address them deeply to avoid any confusion. This barrier was evident in the focus group discussion when only one of the ten participants was able to identify the information gap in the activity and used additional resources other than the textbook. On the top of that comes their perceptions of science, as they consider themselves biology teachers who are not required to deal with non-biological concepts or to cooperate with non-biology teachers. In this context, 56% of the participant asserted that they refuse to cooperate with physics and chemistry teachers, reflecting their view of science as separate disciplines, which is the logical outcome of adopting a disciplinary curriculum. This attitude may also be due to their teaching preparation program that does not enable them to approach the integrated concepts as scientists, contradicting the core value of the nature of science which deals with science as one paradigm (Chalmers, 1999; Lederman, 2013).

Students misconceptions were also considered as main barrier for conceptual integration, as teachers avoid recalling information from the other disciplines because students always have misconceptions in those areas of knowledge. The teachers considered that Conceptual Integration may lead them into a path different than the one they had planned for, as they may be obliged to clarify and correct the misconceptions of the integrated concept, which can be time consuming and confusing for them, being not well trained to deal with such situations.

Conclusion

The main purpose of the study was to investigate Biology teachers' views about and practice of Conceptual Integration in biology. The results show that there are differences between how teachers perceive conceptual integration and how they practice it in class. In fact, although they all acknowledge the integration of physics and chemistry in biology and the necessity of mobilizing students' conceptions to reach conceptual integration, they do not quite apply it into their practice. Many factors lie behind those findings, mainly the curriculum, students' misconceptions and teachers' view about science. In addition, the study reveals that teachers lack the pedagogical knowledge about what Conceptual Integration is and how it should be implemented in class. They are not well equipped with the adequate strategies, tools and assessment for successful implementation of Conceptual Integration. The findings of this study are consistent with those reported by similar studies about Conceptual Integration (Taber, 2008; Tuysuz et al., 2016).

Recommendations

The Lebanese school science curriculum should be reformed in order to become an integrated curriculum that deals with science as one paradigm. In addition, the findings of the study shed the light on the urge to revisit the teacher education program at the Faculty of Education at both the pedagogical level to include Conceptual Integration as a main strategy to teach Sciences and at the content knowledge level to highlight the one paradigm of science that includes various science disciplines sharing the same features of the "nature of Science".

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Author Information

Hanadi Chatila
Lebanese University
Beirut, Lebanon
Contact E-mail:Hanadi.chatila@ul.edu.lb