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Investigating Science Misconceptions of Pre-service Early Childhood Education teachers at the Lebanese University, Faculty of Education

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Abstract: Teacher preparation programs aim mainly to develop both pedagogical and content knowledge of pre-service teachers. Graduate teachers should master all concepts and approaches related to their teaching field. In the Lebanese context Early Childhood Education (ECE) graduates should be able to teach languages, science and math from Kindergarten to grade 3 (K-3). As science educators at the Lebanese University, Faculty of Education, the researchers noticed that ECE pre-service teachers lack mastery in basic scientific concepts. This research aims to identify science misconceptions, compare ECE pre-service science teachers' conceptions over the three years, and propose new strategies and techniques to overcome any misconceptions. For this purpose 150 pre-service ECE teachers distributed over the three year of the ECE preparation program completed an open ended questionnaire to merge their conceptions. Quantitative and qualitative analysis of the data collected was performed. Results show that pre-service ECE teachers hold major scientific misconceptions over the three years in all science related areas.

Keywords: ECE preparation program, Science misconceptions, Conceptual change

Introduction

Pre-service Teacher Education Programs

Teacher preparation programs (TPPs) are generally designed to enable prospective teachers gaining a foundation of knowledge about pedagogy and subject matter, as well as offering them early exposure to practical classroom experience (Feuer et al., 2013).

The National Council for Teacher Education has defined teacher education as a program of education, research and training of candidates to teach from preprimary to higher education level. Some of the most important objectives of teacher education are as follows: 1. Imparting an adequate knowledge of the subject matter; 2. Equipping the teachers with necessary pedagogic skills; 3. Enabling the teacher to acquire understanding of child psychology; 4. Developing proper attitudes towards teaching; 5. Developing self-confidence in the teachers; 6. Enabling teachers to make proper use of instructional facilities; 7. Enabling teachers to understand the significance of individual differences of child (National Council for Teacher Education, NCTE, 2010).

Teacher Education Program in Early Childhood Education (ECE)

Early Childhood Education (ECE) aims at total child development in a learning environment that is joyful, child-centered, play and activity-based. Teacher education programs in ECE should develop in the trainee concepts, competencies, attitudes and skills related to implementation of developmentally appropriate

curriculum based on: cognitive and language development, health and nutrition, social, emotional, physical and psychomotor development, aesthetic development, creativity and play, program planning and school organization, community mobilization and participation. These requirements call for a teacher educator who has a sound educational philosophy of ECE, besides specialized content and methodology skills pertaining to the above areas (NCTE, 2010).

According to Liang (2009) ECE training programs do not focus on teaching science. ECE teacher feel more confident while teaching languages, math and social studies, than teaching lessons about scientific exploration. Furthermore, many ECE teachers claimed that they are less prepared to teach science compared to other disciplines (Wenner, 1993). According to 1997 National Education Goals Report, ECE teachers felt unable to teach science (National Education Goals Panels, 1997). ECE pre-service teachers take few science related courses (Khalid, 2001). However, teachers play an important role in reducing the misconceptions of students, for that reason, it is important for teachers' and pre-service teachers' training programs to pay special attention to teachers' misconceptions (Kanli, 2014).

Overview of the Faculty of Education of the Lebanese University

The mission of the Faculty of Education of the Lebanese University is educating early childhood, elementary and high school teachers, in addition to other pedagogic frameworks. It grants Bachelor degrees in Education and Teaching Diplomas in different specialized majors, as well as Professional Master Degrees (Lebanese University Official Website). Similar to American and Bologna-reformed European systems of higher education, Lebanese higher education utilizes three progressive cycles: Bachelors level (3 years), Masters level (2 years), and Doctoral level (3 years), or the French model, Licence, Master, and Doctorat (LMD). The Lebanese University has begun implementing this three-cycle structure in their faculties in 2005, though implementation has not been immediate or uniform. Noting that, the language of instruction in Lebanon can depend on the institution attended, but programs of study are typically offered in Arabic, English, or French. (El Takach, Rawas & Dokmak, 2018).

ECE Pre-service Teaching Program at the Lebanese University, Faculty of Education

At the Lebanese University, Faculty of Education pre-service ECE teachers undergo three-year teacher preparation courses, following LMD program. The program includes formal university studies with practical experiences in schools. In the Lebanese context Early Childhood Education (ECE) graduates should be able to teach languages, science and math from K-3. The courses typically comprises units in curriculum, psychology, computer fundamentals and its applications, classroom management, evaluation and assessment, human rights, puppet workshop and theater, sociology of education, educating children with special needs, foreign language activities, arabic activities, mathematics activities, action research as well as classroom practice, with a total of 180 credits. The ECE preparation program includes only four courses that are directly related to science: teaching science in ECE; science activities; environmental education; and health education. In addition, there are two other courses which are indirectly related to science: early childhood services and care and an observation course. Throughout those years student-teachers are encouraged to develop their reflective skills through different means, especially practicum courses through practicing micro and macro teaching, writing reflection papers, portfolios and projects.

Conception, Misconception and Conceptual change

Giordan (1987) defined conceptions as a set of images that learners possesses before any teaching process. Giordan and De Vecchi (1987) defined conceptions as "a set of explanatory, coordinated ideas, and coherent images used by learners when confronted with a problematic situation". According to Astolfi (1997) learners have already-there existing ideas that even if it is scientifically wrong serves as a functional explanation for them. Clément (2006) emphasized that conceptions are the results of the interaction between knowledge, values and practices according to the KVP Model. Conceptions in didactics are learners' previously held ideas related to a scientific topic, these previous ideas, can be more or less organized, more or less coherent, more or less scientific (Clément, 2010).

The term misconception or alternative conception simply means an idea or explanation that differs from the accepted scientific concept. A misconception can be defined as the knowledge of an individual about a

concept that is essentially different from the commonly endorsed scientific implication of this concept (Yağbasan & Gülçiçek, 2003). Some alternative conceptions arise as students try to make sense of the world and naturally occurring phenomena around them. Other alternative conceptions form when students construct explanations with insufficient information. Also, alternative conceptions can also result from incorrect or partially correct explanations given by teachers, parents, or the media. The role of the media can be considered an important factor in creating confusions and misconceptions among students. The influence of the media was seemingly a major factor in developing student knowledge and shaping their thinking. The presence of misconceptions can also be attributed to ineffective classroom science instruction. Some students, during the conversation, complained that their science classes did not have any real impact on their knowledge (Khalid, 2001). Once formed, alternative conceptions can be persistent even in the face of discrepant events or careful instruction. According to Wandersee, Mintzes and Novak (1994) often science teachers possesses the same alternative conceptions as their students (as cited in Chiappetta & Koballa, 2010). Student teachers' conceptions could affect the teaching approaches the student teachers eventually take in the classroom (Gustafson, & Rowell, 1995).

However, alternative conceptions are developmental in nature, they often change as students develop their ability to think abstractly (Chiappetta & Koballa, 2010). For many science topics, there are certain instructional strategies that seems promising in moving students towards more scientifically accepted ideas. Driver (1988) proposed an instructional strategy for conceptual change which leads to conceptual development of students' initial ideas toward more scientific conceptions. In this strategy the teacher begins with orientation which focuses on what to be learned; this is followed by elicitation where students are asked to present their ideas of the concept under study; then the teacher probes students to clarify their ideas; then he creates a discrepant event that causes students to see that their conceptions may be incorrect (conflict); then students are engaged in a variety of learning activities to acquire the desired conceptions (construction phase); then the teacher should evaluate students' learning; then students can apply their knowledge in a new situation; finally, the teaching experience ends by a review of what is learned by asking students to describe how there conceptions changed (as cited in Chiappetta & Koballa, 20101). Another important instructional model for inducing conceptual change is the 5 E learning model which is compromised of the following stages: Engagement: arise the interest of students, determine what they know about the topic and motivate them to learn more. Exploration: design an instructional event to give students concrete experiences with the key concepts of the topic. Explanation: encourage students to explain their finding; provide plenty of time for discussion, build from students' findings toward defining, explaining and describing the concepts that are the focus of investigation. Elaboration: give students more instructions so that they might form rich connections with what they know and what they are expected to learn; show applications of the concepts related to everyday life. Evaluation: Assess what students are learning at many points during the instruction. End the 5 phases with an assessment to measure how well students mastered the instructional objectives.

Problem of the Study

According to the study of Ayoubi (2017) there is scarcity of research done in science education: from 6545 publications, only 122 are related to science education and only 2 were addressing science in primary classes or 0.03% of the sample based on analysis of research in education in the Arab World between 2011 and 2015

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As science educators at the Lebanese University, Faculty of Education the researchers noticed that ECE pre-service teachers do not master the science subject matter content knowledge. When pre-service ECE teachers were presenting their science related projects in the course of teaching science many misconceptions were diagnosed by the researchers. The pre-service teachers have either incorrect or wrong scientific knowledge related to major scientific concepts taught at preschool and primary school.

Student teachers enter the classroom with a range of conceptions of science as a result of their past experiences and opportunities related to science (Hassard, 1990). Science teacher educators should consider the repertoire of conceptions brought by student teachers during the training program (Aguirre, Haggerty, & Linder, 1990). The aim of this research is to investigate science misconceptions of ECE-pre service teachers, compare ECE pre-service science teachers' conceptions over the three years and propose methods for conceptual change.

Methodology

This study implemented a mixed research design where both quantitative and qualitative data were collected to investigate science misconceptions of pre service-ECE teachers enrolled at the Lebanese University, Faculty of Education.

Participants

150 pre-service ECE teachers in the Lebanese University, Faculty of Education, distributed over a three-year preparation program during the academic year 2018-2019 participated in this study. 54 participants were enrolled in the 1st year; 40 in the 2nd year and 56 in the 3rd year. In each year the students are distributed over three sections: Arabic, French and English with majority as females.

Instrument

Open-ended questions are one among the various methods used in measuring misconceptions (Tsai & Chou, 2002). In this study an open-ended questionnaire composed of 11 items was administered in order to infer science misconceptions of pre-service ECE teachers at the Lebanese University, Faculty of Education. The items of the questionnaire covered the major science concepts taught from K-3 according to the Lebanese curriculum. Seven items of the questionnaire were related to biology: open ended questions about plants' needs, importance and benefits of plants, body systems and organic food groups; a concept map to be completed about the five senses; and a schema to be drawn by participants related to pathway followed by food inside the body. Two items of the questionnaire were related to chemistry about states of matter and water cycle and another two items related to physics about mass, density and weight.

The questionnaire was first written in English and piloted on 10 pre-service teachers that did not participate in the study, then some items were adjusted based on the results. Then, the questionnaire was translated to French and Arabic by specialists in the field of science education. It was administered in the presence of at least one of the researchers of the study.

Data analysis

Students' answers were analyzed according to the criteria presented in table 1.

Table 1. Criteria of data analysis

Questions		Criteria		
	Biology questions	**Complete**	**Incomplete**	**Wrong**
1.	State the essential elements that a green plant needs for its growth.	State the four elements: H2O and minerals, CO2, Chlorophyll and light	States three or two elements out of four	State Less than two elements
2.	In your opinion, what would happen if all plants disappear?	State the three criteria (level of oxygen decreases, amount of biomass decreases and disequilibrium) that lead to death (no life)	State the three criteria without no life	None
3.	In your opinion, what is the importance of plants in our life?	The importance related to three aspects: Environmental: purifying air Economic: gives fruits, decoration, paper, petrol… Society: decorative.	Provide two aspects	None
4.	Complete the following diagram: the first row (1) with the sense and the second row (2) with the corresponding organ.	Write the five senses and their organs correctly	One sense or organ missing	More than one sense or organ is missing

5.	State the body systems	State the twelve systems	One to Four systems are missing	State less than eight systems
6.	Name the four organic food groups with one example of food for each.	Name the four organic groups: proteins, lipids, carbohydrates and vitamins	One group is missing	More than one group is missing
7.	Draw the labelled pathway (with arrows) of a piece of cake in your body starting from the mouth.	All the labelled organs of the digestive system and the absorption and the pathway presented by arrows	All the labelled organs of the digestive system and the pathway without absorption	Some labelled organs or none without pathway and/or absorption
Chemistry questions		**Complete**	**Incomplete**	**Wrong**
8.	Draw the water cycle in the box including all the processes.	All the processes are mentioned: evaporation, condensation and precipitation	One process is missing	More than one process is missing
9.	Draw the particles of water in the three states	The three drawings are correct	One is not correct	More then one is not correct
Physics questions		**Complete**	**Incomplete**	**Wrong**
10.	Why does oil float on the top of water?	The density of oil is less than the density of water	The term "density" is not used e.g Water is heavier than oil	Wrong answer
11.	What is the difference between mass and weight?	The two definitions are correct	One is not correct	None

Results and Discussion

The questionnaire administered to the 150 participants was composed of 11 open ended questions distributed over the three science subjects: biology, physics and chemistry.

Figure 1 shows the results related to biology focusing on plant needs, benefits and importance, systems of the body, the five senses, the organic groups of food, and the pathway followed by food in the body.

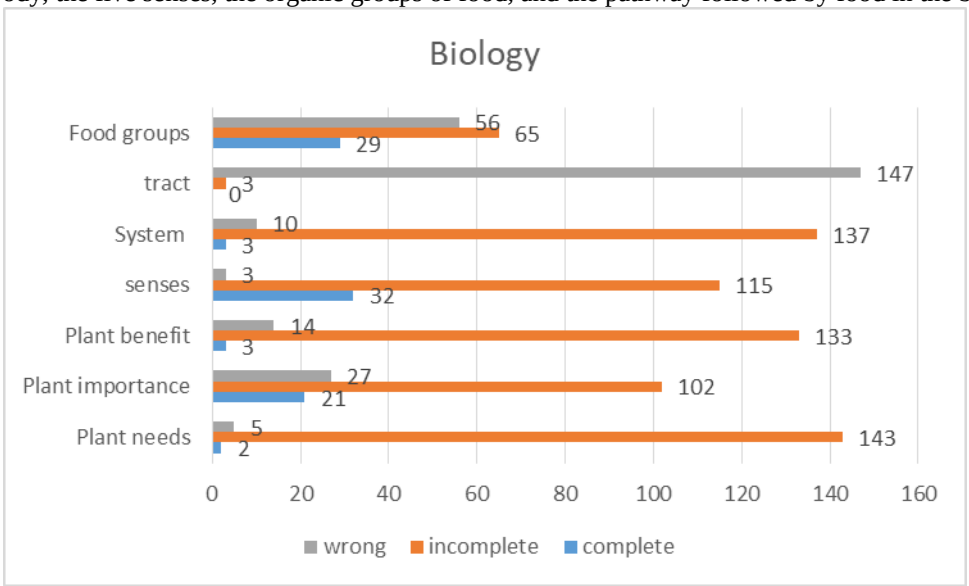

Figure 1. Answers related to biology questions

The results show that the majority of pre-service ECE teachers have incomplete or incorrect ideas related to the basic biology concepts that is taught at the kindergarten and elementary level, first cycle.

Participants were not able to identify all plant needs, only 2 out of 150 mentioned the importance of chlorophyll for green plants to manufacture their organic food. Very few mentioned minerals, others mentioned sun as the only source of light and others mentioned air without specifying CO2. Thus, we might conclude that the majority of participants have misconceptions related to needs of green plants. Based on previous research students tend to give plants human characteristics, especially when it comes to considering what plants need to grow (Abou Ali,1999). The role of light and nutrients in plant growth seems to be especially difficult for elementary students. For example, students may view sunlight as useful but not essential for plant growth. According to Giordan & De Vecchi (1990) the major students' misconception is that plants take in all the substances they need to grow from the soil.

In addition, only 14 % of the participants mentioned that without plants there is no life. The majority of the answers focused on the release of oxygen, few mentioned disequilibria in the food chain. Only 2 % mentioned the three-axis related to the benefits of green plants: the environmental, economic and social. Thus, there is a misconception related to the vital role played by green plant in nature.

Related to the five senses only 21 % answered completely and the majority have incomplete or wrong answers specifically related to the organ responsible for the sense of touch mentioning the hand or leg instead of the skin. This is a common misconception in children and obviously in adults too.

As for the systems of the body only 2 % were able to mention all the 12 systems and 91 % have incomplete answers mentioning between 3 to 6 systems maximum. The most common systems mentioned were the digestive system, the respiratory system, the circulatory system, the reproductive system, the excretory system and the nervous system. The incomplete knowledge of ECE pre-service teachers about the systems of the body might lead to misconception related to interactions between these systems to perform proper body functions.

Moreover, when the participants were asked to draw the pathway or tract followed by food inside the body most of them drew a complete continuous tube from mouth to anus without mentioning the absorption of food to the circulatory system to be distributed to all body organs. These results are consistent with study of Clement (1991) which identified 5 representations or conceptions: One continuous tube from the mouth till urination (misconception) which was very frequent; two tubes: separate digestive and urinary system (without circulatory system); only digestive system: water comes out of the anus; only urinary system; three systems: digestive circulatory and excretory systems (correct conception or scientific concept). Students think that our systems operate in isolation from each other (e.g. the circulatory, respiratory and excretory systems are not connected to each other). Moreover, some did not mention the organs, others mixed the organs of the digestive and respiratory system and few misplaced the organs (Figure 2). Again, this leads to the conclusion that pre-service teachers have misconception related to interactions between the different systems of the body. Similarly, other studies showed that science student teachers have a lack of knowledge or misconceptions in relation to the digestive system, one of the misconceptions that the student teachers have was that they drew the digestive system as a single open-ended structure which starts in the mouth and ends in the stomach in the shape of a bag. Some student teachers drew the digestive system as organs with no associations with each other (Cardak, 2015).

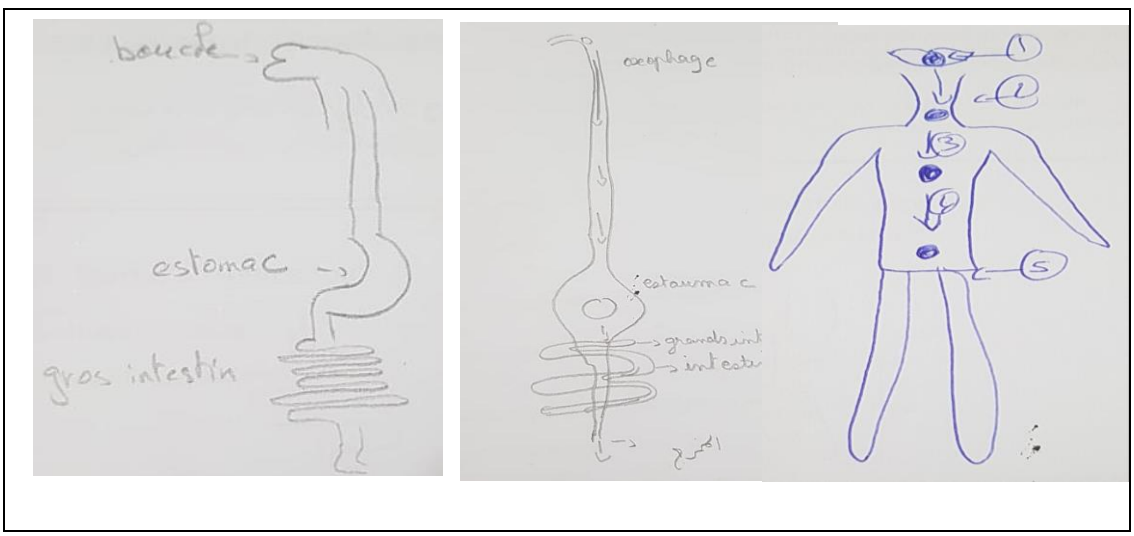

Figure 2. Misconception related to the pathway of food

Finally, only 19 % mentioned all the food groups and the majority did not mention vitamins as an organic food category, others mixed up between minerals and vitamins. This shows a misconception related to classification of food as organic and inorganic.

On the other hand, 4 questions were related to physical science subject about states of matter, water cycle, the relation between mass, weight and density. Figure 3 shows the distribution of the participants' answers related to these questions.

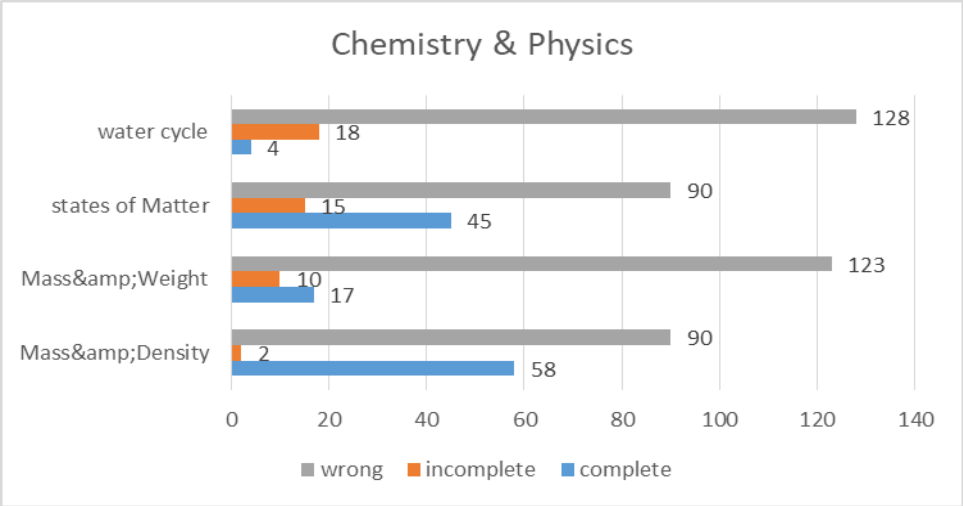

Figure 3. Answers related to physics and chemistry

60 % of the participants had wrong answers when asked why oil floats on water. The analysis of the answers showed confusion between mass and density indicating a misconception related to these physical concepts. In the literature many misconceptions related to floating and sinking were identified: a heavier object, no matter what its size or shape, could not float as easily as a lighter object; a larger, heavier object will not float as well as a smaller, lighter object made from the same material (e.g. a big block of wood and a smaller block of the same wood), an object will float higher in a bigger container of water; In order for an object to float, there must be a greater weight of water than the weight of the object; things float if they are light and sink if they are heavy.

Similarly, 82 % were confused between mass and weight, the majority were not able to define mass, few just mentioned the formula weight= mass x g. Studies show that despite the fact that mass and weight are two fundamental concepts in physics, they are not well understood by students (Gönen, 2008). Mullet and Gervais (1990) showed that the concepts of weight and mass are both understood as one concept, that of weight. Students think that mass and volume are the same and that mass and weight are the same.

In addition, the analysis of the drawings related to the states of matter showed that only 30 % were able to draw the correct figures in the three states. The majority showed a common misconception about matter with the inability to imagine the molecular level drawing ice as cube, water as liquid and gas as air (Figure 4). The misconception is that microscopic particles have the same properties as the macroscopic object they make up: ice particles melt, iron particles rust, all particles expand when heated, concrete particles are hard, cheese particles are soft etc. In congruence earlier studies showed that children have misconceptions related to solid and liquid, they think that substances that are not hard and rigid cannot be solid and particles of solid cannot move while liquid and gases are not completely made up of particles (Stavy, 1990; Stavy & Stachel, 1985).

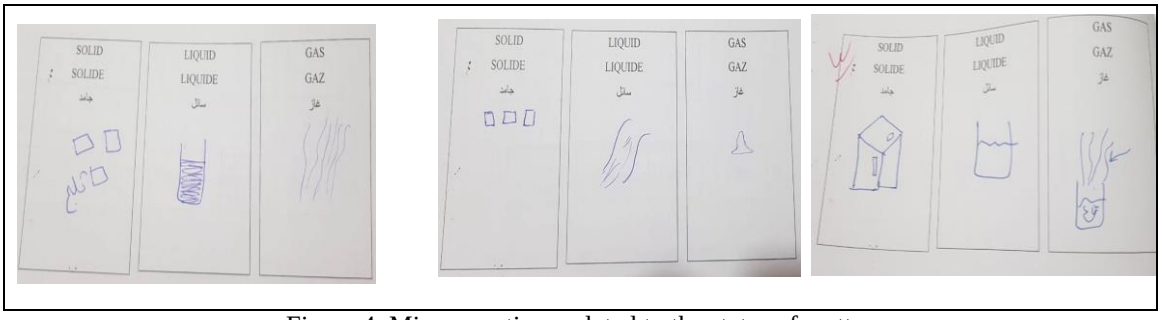

Figure 4. Misconceptions related to the states of matter

85 % of the participants were not able to draw completely and correctly the water cycle. The majority mentioned only evaporation and missed the other processes like condensation, precipitation and filtration (Figure 5). Our results are in congruence with other studies which showed that students have misconceptions related to water cycle. According to Cardak (2009) university students have misconceptions related to water cycle considering only evaporation of water from earth to the atmosphere and its return by condensation.

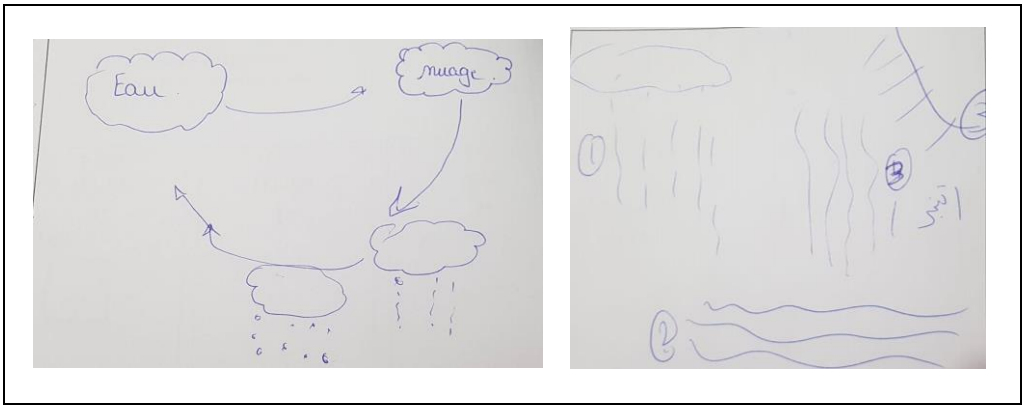

Figure 5. Misconception related to water cycle

In addition, the results related to the 11 questions were compared between the three years, table 2 shows the results related to biology and table 3 shows the results related to chemistry and physics.

Table 2. Comparison between the three years related to biology questions

Biology	Complete			Incomplete			Wrong		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Plant needs	2	0	0	51	40	52	1	0	4
Plant importance	4	3	14	35	31	36	15	6	6
Plant benefit	0	3	0	50	34	49	4	3	7
Senses	8	8	16	43	32	40	3	0	0
Systems	1	0	2	49	38	50	4	2	4
Tract of food	0	0	0	2	1	0	52	39	56
Food groups	12	7	10	21	19	25	21	14	21

The analysis of the data shows approximately the same results in the three years related to plant needs, plant benefits, senses, systems and food groups. Slight difference related to importance of plants. This shows that there is no evolution in pre-service ECE teachers' conceptions over the three years of the preparation program implemented at the Faculty of Education at the Lebanese university. Thus, the courses related to science taken by pre-service teacher over the three years did not lead to any conceptual change related to major biology concepts taught at the classes that they are supposed to teach (K-3) after they graduate.

Table 3. Comparison between the three years related to physics and chemistry questions

Physics & chemistry	Complete			Incomplete			Wrong		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Mass & Density	21	17	20	2	0	0	31	23	36
Mass& Weight	5	0	12	5	1	4	44	39	40
States of Matter	11	18	16	2	4	9	41	18	31
Water cycle	1	1	2	6	5	7	47	34	47

Similarly, the data presented in table 3 show approximately the same results in the three years related mass and density, mass and weight and water cycle. Slight difference related to states of matter. Thus, the same can be concluded related to misconception in major physical science concepts that persisted through the three years of the preparation program.

Conclusion and Recommendations

Our study aimed to investigate science misconception among pre-service ECE teachers following a three years preparation program at the Lebanese University, Faculty of Education. The results identified many misconceptions related to basic science concepts taught in KG and cycle 1 (K-3) in the Lebanese curriculum. Moreover, the misconceptions were common among pre-service ECE teachers throughout the three-year preparation program. Thus, our study highlights a major gap in the ECE preparation program at the Lebanese University related to science conceptual understanding. The direct and indirect science courses taken did not lead to any conceptual change among ECE pre-service teachers. Therefore, we recommend adding more courses related to science and teaching for conceptual change. This is consistent with the study of Liang (2009) which recommended courses involving children's science education in pre-service ECE teachers' preparation programs. Similarly, the study done at the Lebanese University, Faculty of Education, by El Takach (2018) emphasized on the need for adding more science courses for ECE teachers related to the nature and history of science. According to many researches, science may be a particularly important domain in early childhood, serving not only to build a basis for future scientific understanding but also to build important skills and attitudes for learning. To fill this gap, we highly recommend the implementation of new teaching strategies like 5 E model for conceptual change that is to make conceptions change or evolve towards real scientific concepts. According to the study performed by Shaaban & Abou Ali (2018) the implementation of inquiry-based teaching methodologies integrating technology during a training program for in service biology secondary teachers enhanced their scientific knowledge and skills. Similarly, the study of Sarabando, Cravino & Soares (2016) showed that the use of computer simulation helped the students to understand the concepts of weight and mass.

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