

## **The Development of Science Education Pedagogical Content Knowledge Competences in the Early Childhood Teacher Education Program at the Lebanese University, Faculty of Education**

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**Abstract:** This paper investigates to what extent the Early Childhood Education (ECE) initial teachers education preparation program at the Lebanese University Faculty of Education, develop pre-service teachers' Pedagogical Content Knowledge competences (PCK) to teach science for early years. For this purpose, an original analysis framework was developed by the researchers after extensive review of the existing literature and theories covering science education for early childhood education teaching program. To assess the development of science education PCK competences over the three years of the program, a questionnaire, developed and validated by the researchers, was completed by 56 graduate ECE pre-service teachers, measuring the content knowledge. In addition, content analysis of the science lesson plans completed by the pre-service teachers during their training sessions and retrieved from their portfolios, associated with an interview with their trainers. The findings show that competences related to content knowledge are not developed, whereas the development of other competences varies between not and fairly developed.

**Keywords:** Science education, Early childhood education, Pedagogical content knowledge, Competences

### **Introduction**

Young children have intuitive curiosity that enables them to practice scientific inquiry as a natural relationship with their very direct environment as an epistemological component of their adaptation. This practice takes place on both practical and conceptual levels. Zeece (1999) considers that children are engaged in scientific thinking and practice long before their schooling year.

When investigating Early Childhood Education (ECE), the developmental stage must be defined. Lebanon embraces the UNESCO 's definition for this stage "Early childhood, defined as the period from birth to eight years old, is a time of remarkable growth with brain development at its peak", UNESCO. (n.d.).

This period in the Lebanese educational system is divided into three sub-stages: First, from birth to three years old, in which kids stay at home or attend daycare due to the choice and needs of the family. Second, from three to six years old, in which children attend kindergarten which is not obligatory, but all the Lebanese children attend two till three years. And the final third stage from six to eight years old which is the first cycle of the elementary education.

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## **Science Education in ECE**

The importance of teaching science is that it can enable us to think critically. Without scientific knowledge, we are wholly dependent on experts. So, science empowered people to become active citizens rather than observers (El Tacksh, 2018; Michaels, Shouse & Schweingruber, 2008).

Young children are non-stop explorers, they start exploring their environment on their own at an early age. While exploring, they develop their capacities to observe and discover the world around them (Jirout & Zimmerman, 2015), and therefore they tend to construct their own concepts and generalize them as they are growing. And this natural process as a developmental side can be more convenient and supportive to child's developmental needs.

According to National Science Teachers Association NSTA (n.d) learning science in the early ages is characterized by:

- 1- Young children have the ability and the capacity to engage in scientific practice. And they can learn science on a conceptual level in addition to practice.
- 2- Young children learn science more accurately when adults prepare and enrich the environment with the supportive setting.
- 3- The more young children have exposure to exploration and experimentation, the more they have chances to develop their own scientific skills and knowledge. The enriched environment allows more chances to observe patterns, propose hypotheses, and construct their own knowledge.
- 4- Young children can inquire science in both; formal prepared settings, and informal settings. Through playing and their daily life
- 5- Young children accumulate scientific knowledge and skills and can transfer them to another subjects.
- 6- Young children can learn more deeply when they share positively in the activities.

### *Young Children and Scientific Inquiry*

People think differently about science. Some consider it as a pure fact known as "school science" and others see it as a body of knowledge that includes along with facts and concepts laws, theories, and models that may explain how does the natural world work.

However, science educators perceive it, in addition to the body of knowledge, as an "inquiry" in other words the process of investigating and finding out.

Science inquiry refers to "the diverse ways in which scientists study the natural world and propose explanations based on evidence from their work" (National Science Research Council, 1996, p. 23).

Early Childhood educators highlight the rationale behind the importance of science in the early childhood classroom, on the basis on a number of variables. Stakeholders suggest that children at their early stages have a great potential to learn and therefore they should be provided with a rich and challenging environment for their learning, with the recognition of the power of their thinking and learning (Worth, 2010). Early Childhood Science Education plays a key role in the development of life skills and promoting positive attitudes towards learning. Research studies have reported its impact on student career interest in science or engineering more than in another grade level (Anders et al., 2012).

The development of scientific thinking is considered as a main goal of the early childhood science curriculum. Therefore, when talking about science for young children, it is assumed that it would be a blended interplay that includes in addition to scientific facts, that are extremely important to enable children build their own understanding of basic concepts, also that blended knowledge includes inquiry which is well elaborated through scientific reasoning, the nature of science, and doing science, where young children are guided to ask questions and conduct investigations.

To assure the right challenging environment, stimulate the scientific curiosity and develop the thinking skills, the focus should be on the curriculum and also on the teachers, mainly on the teacher initial preparation programs.

## **Early Childhood Pre-service Teaching Program at the Lebanese University, Faculty of Education**

At the Lebanese University, Faculty of Education pre-service ECE teachers course adapts the LMD program that was implemented in 2009-2010. The program comprises theoretical formal courses along with practical ones in schools and childcares. It aims mainly to develop the pre-service teachers Pedagogical Content Knowledge PCK competences by providing various courses units in curriculum studies, child psychology, classroom management, evaluation and assessment, teaching methodology, action research and others as well as classroom practice, and content courses related to science, math and languages, with a total of 180 credits.

Noting that the program offers the degree in three main languages, Arabic, French and English and the language of instruction varies accordingly, but all pre-service teachers receive the same degree at the end of the three years of preparation.

### *Science Education in ECE at the Lebanese University, Faculty of Education*

Science education is present in the program, in both theoretical and practical courses. There are four theoretical courses that are directly related to science, where only one addresses the pedagogical knowledge and the other three are content related. In addition, there is one theoretical course that includes scientific themes.

The theoretical courses names, descriptions and time of delivery in the program and are presented in the table below.

Table 1. ECE science education theoretical courses

<b>Course</b>	<b>Description</b>	<b>Time of delivery</b>
Health and Nutrition	Content knowledge	First year
Science Activities	Content knowledge	First year
Teaching Science for ECE	Science education pedagogical knowledge	Second year
Early Childhood Services and Care	General ECE pedagogical knowledge	Second year
Environmental Education	Content knowledge + pedagogical knowledge	Third year

In addition to the theoretical courses, science education takes part in the three practical courses that are distributed over the second and third year of the program. Throughout those practical courses, pre-service teachers are to observe teaching sessions, practice micro and macro teaching and design their own portfolios. Pre-service ECE teachers are required to observe, prepare and practice science activities for preschoolers and science lessons for cycle one students (grades 1-3). All the preparations and reflection papers they write are kept in their portfolios.

## **Problem of the Study**

Being science and ECE educators at the Lebanese University, Faculty of Education, we have noticed that ECE pre-service teachers face difficulties in science content knowledge. Their practice showed that they hold many scientific misconceptions about basic scientific concepts taught at preschool and primary school, due mainly to incomplete or wrong scientific knowledge related to those concepts.

The aim of this research is to investigate to what extent the Early Childhood Education ECE initial teachers education preparation program at the Lebanese University Faculty of Education, develop pre-service teachers' PCK competences to teach science for early years.

## **PCK Components Related to the Present Research**

According to Shulman (1987), the general description of PCK includes three main components: knowledge of topics regularly taught in the subject area, the knowledge of forms of representation of those concepts, and the knowledge of students' understanding of the topics.

Research in PCK have developed many frameworks and expanded the components of PCK (van Driel, Berry & Merinik, 2014; Alonzo, Kobarg & Seidel, 2012). This research aims to investigate ECE pre-service teachers PCK to teach science, and it is assumed that the graduate ECE teachers should master all the scientific concepts

related to their areas of teaching, that matches with the Lebanese ECE curriculum requirement in science, and all the pedagogical knowledge related to science teaching methods and assessment. The suggested PCK components for this study are presented in figure 1 below:

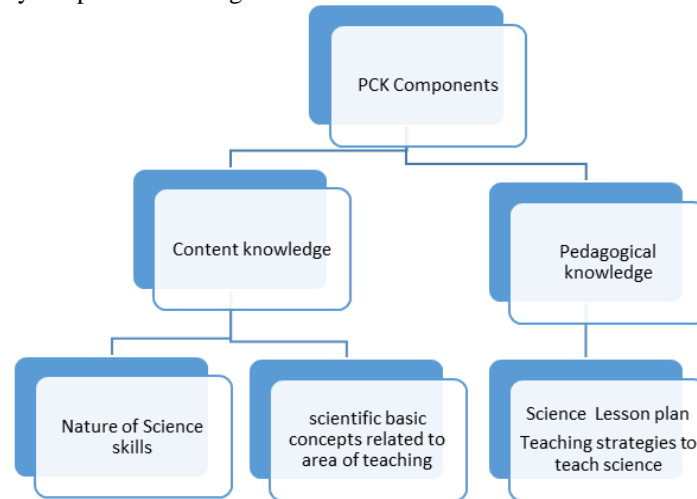


Figure 1. ECE pre-service PCK components to teach science

Related to the content knowledge, the scientific themes required by the Lebanese curriculum in Preschool and cycle one, are presented in tables 2 and 3 (Center for Educational Research and Development, CERD, 1997).

Table 2. Scientific themes required by the Lebanese curriculum for preschoolers (CERD, 1997)

Theme	KG1	KG2
People and their community	Man (Senses) Professions Transportation	Food Professions Transportation Means of communication Machines
Natural environment	Animals Plants Seasons	Animals Plants Rocks Air Water

Table 3. The scoop and sequence of science in cycle one (CERD, 1997)

Theme	Grade one	Grade two	Grade three
Plants and their habitats	<ul style="list-style-type: none"> <li>Growth and needs of plants</li> </ul>	<ul style="list-style-type: none"> <li>Parts of a garden</li> <li>Seasonal plants</li> </ul>	<ul style="list-style-type: none"> <li>Parts of a plant</li> <li>Forest, desert and sea plants</li> </ul>
Animals and their habitats	<ul style="list-style-type: none"> <li>Growth and needs of animals</li> </ul>	<ul style="list-style-type: none"> <li>Similarity, variation and difference in animals</li> </ul>	<ul style="list-style-type: none"> <li>Forest, desert and sea animals.</li> <li>Sea pollution</li> </ul>
Man and the environment	Included in the other themes.	Included in the other themes.	Included in the other themes.
Matter and Energy	<ul style="list-style-type: none"> <li>The sun.</li> <li>Clouds.</li> <li>Air Water</li> </ul>	<ul style="list-style-type: none"> <li>Nonliving things.</li> <li>Water cycle.</li> <li>States of water</li> </ul>	<ul style="list-style-type: none"> <li>Heat sources.</li> <li>Properties of states of matter.</li> </ul>
Earth and the Universe	<ul style="list-style-type: none"> <li>Day and night.</li> <li>The four seasons</li> </ul>	<ul style="list-style-type: none"> <li>Apparent movements of sun.</li> <li>Movement of shadows.</li> <li>Times of day</li> </ul>	<ul style="list-style-type: none"> <li>Force concept</li> <li>Phases of moon.</li> <li>Temperature.</li> <li>Breakdown of rocks</li> </ul>

Moreover, the Lebanese curriculum emphasizes on developing children’s science skills (NOS) like observation, analysis, discovery, deduction and problem-solving skills in order to acquire knowledge based on their personal experiences and their interaction with the surrounding environment (CERD, 1997).

Three research questions are addressed in this study

- 1- To what extent ECE pre-service teachers master the major and basics scientific concepts required to teach ECE science?
- 2- To what extent ECE pre-service teachers master the pedagogical knowledge required to teach ECE science?
- 3- What are the challenges faced by ECE pre-service teachers when teaching science?

It is assumed that if ECE pre-service teachers can master the basics scientific concepts of the topics related to their teaching areas and the nature of science NOS skills then they have developed their content knowledge. It was also assumed that if they can prepare a science lesson and use a variety of strategies in their teaching, then they have developed their pedagogical knowledge.

## **Method**

This is a descriptive study that aims to explore ECE pre-service teacher’s science education PCK competences development after attending the initial preparation program at the Lebanese University, Faculty of Education. So, for its exploratory nature a mixed research design where both quantitative and qualitative data were collected to answer the research questions. A questionnaire, science lesson plan analysis and an interview were conducted.

## **Participants**

A convenient sample from third year ECE pre-service teachers was selected to participate in the study. The sample included Fifty-six participants distributed over three sections: Arabic, French and English. All participants had completed the science related theoretical courses presented in table 1, three practical units and were undergoing the fourth one. In addition, three trainers were interviewed.

## **Data Collection and analysis**

### *Questionnaire*

A questionnaire of 19 items distributed over two sections was developed by the researchers. The first section includes twelve open-ended items that cover the major science concepts taught from kindergarten to grade three according to the Lebanese curriculum. Eight items of the questionnaire cover biology concepts, two items for chemistry and another two for physics. The second section comprises seven multiple choice questions about Nature of Science skills. A description of the questionnaire is presented in table 4.

The questionnaire was first developed in English language and completed by ten ECE pre-service teachers that did not participate in the study, for piloting. Based on the results, some items were adjusted. Then, the questionnaire was translated to French and Arabic by science educators.

The table below describes the questionnaire sections along with their related items and the targeted measurement of each.

Table 4. Sections and items and intended measure of the questionnaire

<b>Sections</b>	<b>Items</b>	<b>Measure</b>
Section 1	12 open-ended questions <ul style="list-style-type: none"> <li>• 8 items biology:                             <ul style="list-style-type: none"> <li>○ plants’ needs, importance and benefits</li> <li>○ body systems</li> <li>○ organic food groups</li> <li>○ the five senses</li> </ul> </li> <li>• 2 items chemistry:</li> </ul>	Mastery of scientific concepts related to science ECE teaching in Lebanon

- State of matter
- Water cycle
- 2 items physics
  - Mass and weight
  - Density

Section 2

7 multiple choice questions

Nature of Science skills

Participants’ answers of the first section, of the twelve open-ended questions were analyzed according to the following criteria:

- “complete”: the answer is correct and complete
- “incomplete”: the answer is not complete
- “wrong”: the answer is wrong, not relevant to the question or no answer

Whereas the answers of the second section were classified as “correct” and “wrong”.

### Science Lesson Plan

The science lessons prepared by the participants were retrieved from their portfolios and used to measure to what extent the pre-service teachers have developed their pedagogical knowledge to teach science.

The analysis framework was developed by the researchers and adapted from the pre-service competences’ framework developed by Chatila, Abou Ali, Naccache & Raad (2019). It included five sections with various items.

The table below presents the framework of ECE science lesson plan analysis.

Table 5. Lesson plan analysis framework

Scale	Items
Learning outcomes	<ul style="list-style-type: none"> <li>● Specify accurately the learning objectives (outcomes)</li> <li>● Diversify the outcomes according to Bloom's taxonomy (cognitive outcomes)</li> <li>● Diversify the outcomes according to Simpson's taxonomy (psychomotor outcomes)</li> <li>● Diversify the objectives according to Krathwohl’s taxonomy (affective outcomes)</li> </ul>
Resources	<ul style="list-style-type: none"> <li>● Choose the appropriate resources</li> <li>● Take into consideration students’ prior knowledge</li> <li>● Motivational introduction</li> </ul>
Introduction	<ul style="list-style-type: none"> <li>○ Exploring object materials</li> <li>○ Raising questions</li> </ul>
Teaching strategies	<ul style="list-style-type: none"> <li>● Engaging and simple investigation</li> <li>● Choose the appropriate active learning strategies</li> <li>● Choose learning activities appropriate to the learning outcomes</li> <li>● Use variety of appropriate learning tools and technology</li> <li>● Diversify the learning activities by adopting differentiated learning</li> <li>● Diversify the modalities (team/pairs/individual work)</li> <li>● Allocate time appropriately to activities</li> <li>● Relate the concept to daily life</li> <li>● Plan appropriate alternative activities</li> </ul>
Evaluation	<ul style="list-style-type: none"> <li>● Prepare activities for reinforcement and evaluation</li> </ul>

The computer software SPSS was used to compute response frequencies and percentages for each section. In the analysis, scores were divided into three percentiles and the desired outcome was considered as “non- achieved”, “fairly achieved” and “achieved” according to the following criteria.

- The lowest through the 50 percentiles of the score the outcome is considered as “not achieved”

- Between the 50<sup>th</sup> and the 75<sup>th</sup> percentile, the outcome is considered as “fairly achieved”
- Above 75 percentiles, the outcome is achieved.

#### Trainers’ Interview

Three ECE pre-service trainers were interviewed about the pre-service trainee proficiency in teaching science. The questions of the interview were in line with the PCK framework suggested for this study.

The following questions were addressed:

- 1- How do you assess the ECE pre-service teachers’ performance in delivering a science lesson in terms of
  - a- Content knowledge in science
  - b- Pedagogical knowledge in teaching science lesson
- 2- Do pre-service ECE teachers have any other specific challenges in teaching science?

## Results and Discussion

### ECE Pre-service Teachers’ Mastery of Scientific Content Knowledge

Data analyses of the items of the questionnaire were used to measure the content knowledge of the participant ECE pre-service teachers. The first section, comprised of 11 open-ended questions, was designed to measure the mastery of scientific concepts related to the ECE areas of teaching according to the Lebanese curriculum. Whereas the second section measured the acquisition of Nature of Science skills.

According to data analysis, the total percentage of “complete” answers is 14.13 %, while as for “incomplete” answers is 44.51% and 44.34% for wrong answers. For the “complete” answers, the percentages ranges between 0% to 35.71%, with three items having the percentage 0%. The “incomplete” answers are ranging from 0% to 92.55%, and the “wrong” ones vary between 0% and 100%. The results of the open-ended section are presented in table 6.

Table 6. Distribution of frequencies and percentages of ECE pre-service teachers’ mastery of scientific concepts

Open-ended Items	Answers					
	Complete		Incomplete		Wrong	
	Frequencies	Percentage %	Frequencies	Percentage %	Frequencies	Percentage %
1	0	0	52	92.85	4	7.14
2	14	25	36	64.28	6	10.71
3	3	5.35	7	12.50	46	82.14
4	0	0	49	87.50	7	12.50
5	20	35.71	0	0	36	64.28
6	16	28.57	40	71.42	0	0
7	12	21.42	4	7.14	40	71.42
8	2	3.57	50	89.28	4	7.14
9	16	28.57	9	16.07	31	55.35
10	0	0	0	0	56	100
11	10	17.85	25	44.64	21	37.50
12	2	3.57	7	12.50	47	83.92
<b>Total</b>	<b>95</b>	<b>14.13</b>	<b>279</b>	<b>41.51</b>	<b>298</b>	<b>44.34</b>

Regarding the acquisition of the Nature of Science skills, the results show 48.97% of “correct” answers and 51.02% for “wrong” ones. The “correct answers” ranges from 21.42% to 82.14% and the “wrong answers” from 17.85% to 76.78%. The results of the acquisition of Nature of Science skills are presented in table seven.

Table 7. Distribution of frequencies and percentages of ECE pre-service teachers' acquisition of Nature of Science skills

MCQ Items	Answers			
	Correct		Wrong	
	Frequencies	Percentage %	Frequencies	Percentage %
13	46	82.14	10	17.85
14	12	21.42	44	78.57
15	28	50	28	50
16	13	23.21	43	76.78
17	34	60.71	22	39.28
18	21	37.50	35	62.50
19	38	67.85	18	32.14
<b>Total</b>	<b>192</b>	<b>48.97</b>	<b>200</b>	<b>51.02</b>

### ECE Pre-service Teachers' Mastery of Pedagogical Knowledge

#### Lesson plan

The analysis of lesson plan was performed on the basis of the framework presented in table 4, and the results are presented for each scale.

Regarding the first scale "the learning outcomes", data show that 35.71 % of ECE pre-service have achieved the outcome of the scale, while as 55.35% have fairly achieved them and 8.92% with no achievement. The results of "the learning outcomes" scale are presented in table 8.

Table 8. Distribution of frequencies and percentages of ECE pre-service teachers 'outcomes of "Learning outcomes" scale

"Learning outcomes" Outcome	Frequencies	Percentage %
Not Achieved	5	8.92
Fairly Achieved	31	55.35
Achieved	20	35.71
Total	56	100

For the second scale of the lesson plan analysis "the resources" scale, data analysis shows that 60% of the participants have achieved the outcomes while 26.78% have fairly achieved them and 12.5% with no achievement. The results of the "resources" scale are presented in table 9.

Table 9. Distribution of frequencies and percentages of ECE pre-service teachers 'outcomes of the "Resources" scale

"Resources" Outcome	Frequencies	Percentage %
Not Achieved	7	12.50
Fairly Achieved	15	26.78
Achieved	34	60.71
Total	56	100

Regarding the "Introduction" scale, 89.28 of the participants have achieved the outcome, whereas 7.14% have fairly achieved and 14.28% with no achievement. The results of the "Introduction" scales are shown in table 10.

Table 10. Distribution of frequencies and percentages of ECE pre-service teachers 'outcomes of the "Introduction" scale

"Introduction" Outcome	Frequencies	Percentage %
Not Achieved	2	14.28
Fairly Achieved	4	7.14
Achieved	50	89.28
Total	56	100



In the “Teaching Strategies” scales, 44.64% of the participants have achieved the outcomes, 41.07% with fairly achievement and the rest 14.28% have not achieved them. The results of the “Teaching strategies” scale are displayed in table 11.

Table 11. Distribution of frequencies and percentages of ECE pre-service teachers ‘outcomes of “Teaching strategies” scale

“Teaching Strategies/inquiry” Outcome	Frequencies	Percentage %
Not Achieved	8	14.28
Fairly Achieved	23	41.07
Achieved	25	44.64
Total	56	100

The last scale of the lesson plan analysis is the “evaluation”. Data shows that 48.21% of the participants have achieved the outcomes, 36.28% have fairly achieved them and the rest 12.50 % with no achievement.

Table 12. Distribution of frequencies and percentages of ECE pre-service teachers ‘outcomes of the “Evaluation” scale

“Evaluation” Outcome	Frequencies	Percentage %
Not Achieved	7	12.50
Fairly Achieved	22	39.28
Achieved	27	48.21
Total	56	100

### Interview

The interview included two main questions.

The first question is about the content and pedagogical knowledge of the ECE pre-service teachers. The three interviewee trainers agree that the ECE pre-service teachers face difficulties in content knowledge. They hold many scientific misconceptions.

*“During class observation, I always detect misconceptions in scientific ideas e.g. in plant they always ignore the role of chlorophyll in photosynthesis, also in senses like the organ of the touch is hand instead of skin! In animal system, they can’t relate between two systems in the body especially the digestive and the circulatory system.”*

*“There are a lot of misconceptions, example the vitamins are always considered as minerals not organic. And most importantly they have huge confusion between the concepts of mass and weight”*

In addition to misconceptions, the trainers also agree on the lack of mastery of Nature of science skills. The ECE pre-service teachers have difficulties in some skills like formulating a hypothesis, making predictions, and inferences.

*“The trainers find it hard to infer from an observation. And also, their analysis are always incomplete.”*

*“The Nature of Science skills are not well developed; many of them still can’t write a hypothesis.”*

*“They mostly confuse between prediction and inferences”.*

Regarding the pedagogical knowledge, the trainers considered that the pre-service teachers have developed to some extent the relevant competences. They can introduce well their lesson, apply active learning and diversify the teaching strategies in class. They also try to apply inquiry in their class.

*“They always start the lesson very good; they use motivational technics... but when reaching the explanation part, they start to struggle.”*

*“Our students are developing their strategies; they try always to apply inquiry.”*

*“Some use various active strategies in class, and have the ability to apply active learning. They ask questions, make students to discover the concept and sometimes they relate to everyday life.”*

However, one trainer mentioned that there is a problem in performing experiments.

*“They have fear from experiment, so they avoid it and go for simpler strategies.”*

Another trainer mentioned the schools are not always providing the right environment for inquiry, e.g. big number of students in classroom and lack of materials.

*“Our students are not projecting what they know, because there are limitations in the schools where they perform the practice... young students are not used to cooperative learning, so our pre-service teachers find it hard to apply group work. Also, some schools lack materials for simple experiments.”*

Another issue, is that active learning and inquiry needs strong classroom management, which make our trainers hesitate to apply it

*“They find it risky...they also fear that if the class is not well maintained this may affect their practicum assessment”*

In addition, the three trainers mentioned difficulties faced in lesson plan, especially in writing the learning objectives and outcomes. Moreover, the pre-service teachers always fail to diversify their resources especially when it comes for searching references.

*“Most of the learning outcomes are not well written.”*

*“They need help in writing the lesson objectives.”*

*“Our students don't diversify their resources... they don't search for new resources; they rely on those provided by us or sometimes they share resources between each others.”*

One trainer mentioned an issue in delivering the lesson plan, as there are problems in time and classroom management.

*“I always notice problem in delivering the lesson plan, especially when it comes to time management. They are weak in classroom management that is why they can't follow their written lesson plan.”*

Finally, regarding the evaluation, all the trainers agreed that the pre-service ECE teachers need to better develop their evaluation competencies.

*“Few of our students are able to perform a good evaluation at the end of the session”*

*“There is always a lack in the assessment and evaluation”*

The second question of the interview was about any challenges the pre-service teacher face in class, other than mentioned above.

The three trainers considered that ECE pre-service teachers lack motivation in teaching science, they are not creative and lack awareness of the importance of teaching and learning science in ECE.

*“The trainers are not motivated when teaching science, maybe they don't know the importance of teaching science for young children.”*

*“We notice that they copy the lesson plan from each other, they don't come with new ideas, no creativity. I think this may be due to their weakness in science.”*

Moreover, the trainers stressed on the psychological side of the trainees, by mentioning

*“Some fear applying innovative lesson in class, they fear trying something new!”*

*“Our students feel it is risky to apply active learning in practice because they lack experience.”*

## **Discussion**

Data collected from the questionnaire show that ECE pre-service teachers do not master to some extent content knowledge. only 14.13 % of the items were answered correctly and completely. while as the percentage of “incomplete” and “wrong” answers was 88.85%, distributed as 44.51% for “incomplete” and 44.34% for “wrong”.

In addition, there were three questions where all participants failed to provide “complete” answers. The first question: “State the essential elements that a green plant needs for its growth”. None of the participants mentioned the “chlorophyll”. This result is in line with the trainers interviewees when they mentioned that ECE

pre-service teachers hold many misconceptions and one of the trainers mentioned the ignorance of the role of chlorophyll.

The second question that was missed by the participants was “What is the importance of plants in our life?” the participants were expected to relate the plants to real-life, however they failed to provide a “complete” answer, as they all focused on the environmental benefit of plants “*giving oxygen*” ignoring economical and societal aspects.

The third question was “Draw the labelled pathway of a piece of cake in your body starting from the mouth”. All participants provided “wrong” answer. They failed to connect between digestive and circulatory systems and draw a labelled pathway. This finding is confirmed by the trainer in the interview that mentioned that ECE pre-service teachers find difficulties to connect between body systems.

Regarding the Nature of Science skills, data from the questionnaire show clearly that ECE pre-service teachers lack the acquisition of those skills. Less than half provided “correct” answers 48.97 %. The least answered correctly item is item 16 with 21.42% and was about the steps of scientific investigation, followed by item 18 about “inferences” with 23.21%. This finding is in line with the results from the interview, where the trainers mentioned that ECE pre-service teachers face difficulties with skills, namely formulating a hypothesis, prediction and inferences.

Those findings are in line with Reinoso, Delgado-Iglesias & Fernández (2019) who reported that they detected significant shortcomings in certain content and activities related to scientific methodology.

In addition, El Takach (2018) reported in a study conducted on ECE pre-service teachers at the Lebanese University about their views of science and scientists, that there is an urge to add more science courses in the ECE initial preparation program related to the nature and history of science.

Regarding the pedagogical knowledge of the participants, data collected from their science lessons plans show that outcomes achievement varies between the scales, with a percentage ranging between 35.71% to 89.28%. It can be inferred from this finding, that overall the achievement of the participant is low to fair. To be more specific, in the “learning outcomes” scale only 35.71% of the participants achieved the outcome, while the rest 80% fluctuate between a majority of fairly achievement 55.35% and 8.92% no achievement. This result is enforced by the trainers’ interview findings who mentioned that the pre-service ECE teachers face difficulties in the learning objectives and outcomes of the lesson.

The second least achieved scale is “teaching strategies/inquiry” scale. Less than half of the participants, 44.645 %, achieved the outcome. It is obvious that inquiry is causing a big challenge for them, they try to apply inquiry to some extent and they need more tools to do so.

The trainers mentioned in their interview that the pre-service ECE teachers try to apply inquiry, but some of them avoid it due to two main reasons: lack of confidence in applying active learning and inquiry, and school environment restrictions.

Our findings are in line with Dogan and Simsar (2018). The authors investigated in a case study preschool teachers’ views on science education. They reported that teachers face problems with the lack of teaching materials, crowded classes and inadequate classroom environment.

Regarding the “resources” scale, 60.71 % of the participants achieved the desired outcome of the scale, and 26.78 % with fairly achievement and the rest 12.50% not achieved. The results are supported by the trainers as they considered that ECE pre-service teachers have limited access to resources.

Data from the “evaluation” scale, show that only 48.21% of pre-service ECE teacher are able to prepare activities for reinforcement and evaluation. While 39.28% are still developing the related competences and the rest failed to do so. The trainers again confirm this finding.

The lesson “introduction” scale is the best achieved by the participant with 89.28% of achievement. The participants are in general able to introduce an engaging science lesson. The trainers confirmed this finding and considered that the ECE pre-service teachers are able to motivate students at the beginning of the lesson.

Data from the interview show also that ECE pre-service teachers do not have motivation towards teaching science, and they lack creativity. This may be due to many factors, some stated by the interviewees like the lack of tools to teach science and awareness of the importance of science education in early years. ECE pre-service teachers feel that they are not well prepared to teach science and lack experience. In this vein, Johnson (1999) stated that science is neglected in early childhood classes and referred it to the fact that it is perceived as hard and abstract subjects for both students and teachers.

## **Conclusion**

The study findings show that pre-service ECE teachers at the Lebanese university, Faculty of Education, have fairly developed the competencies related to PCK in science education. Overall, the participants present lack in their scientific content knowledge, they hold many scientific common misconceptions and the skills of NOS are not well acquired. The results are in line with El Takach (2018) findings, who highlights the needs of adding more science courses in ECE initial preparation program at the Lebanese University, Faculty of Education. Similarly, the pedagogical knowledge related competences are not fully developed, and the micro assessment show a various level of achievement between the different axes of pedagogical knowledge, with predominance of fairly achievement level. These weaknesses in both content and pedagogical knowledge have presented a challenge for ECE pre-service teachers when teaching science and a barrier for motivation and creativity. The results are consistent with those reported by Liang (2009) that highlight the need to involve in-depth ECE science education in pre-service ECE teachers' preparation programs.

## **Recommendations**

A reform in the initial preparation program for ECE teachers at the Lebanese University should be considered in terms of course contents, credits and distributions over the three years of the program. More science content courses are advised with innovative strategies for conceptual changes, delivered by science educators. Similarly, more science education courses are needed to empower pre-service teachers with the tools required to teach science in schools.

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