Adam Mickiewicz University of Poznań

# Middle School Science Teachers' Declaration about Meaningful Learning

A Dissertation Submitted to the Faculty of Educational Studies
in Partial Fulfillment of the
Requirements for the Degree
Doctor of Education

by

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September 2019

## ACKNOWLEDGEMENTS

First and foremost, I would like to acknowledge my supervisor, Professor Stanisław Dylak, for providing invaluable contribution to my knowledge and the generation of this thesis. His guidance has continually inspired me, as he dedicated long hours to stimulating discussions, while directing me on the track of interesting research.

I would also like to extend my sincere thanks and appreciation to the members of my dissertation committee for their comments and suggestions which will guide me as I attempt to present this thesis in the best possible manner.

I am grateful to Dr. Orit Hayon and her husband Jacob who have encouraged me and boosted my motivation all the way to complete the thesis.

I sincerely appreciate the teachers who agreed to be interviewed and participate in this project as well as those who judged the questionnaire. This research project would not have been possible without them.

Finally, I would like to thank my parents, my friends and my wonderful family. My wife Shireen, and our sons Nadeem, Toni and Hosam, who provided love, support and encouragement to stay on course throughout this challenging journey.

# ABSTRACT

The current study aims to evaluate science teachers' beliefs in Arab middle schools in Northern Israel and their teaching practice in terms of specific pedagogical components which are crucial for promoting meaningful learning (ML). In addition, this study seeks to determine whether teachers’ beliefs have any relationship with their practice of these components.

The researcher has also explored background factors, such as gender, years of teaching, educational qualification and school type, in order to determine whether they affect teachers' implementation of teaching practices for promoting meaningful learning. In addition, this study attempts to identify obstacles that might impede the implementation of meaningful learning, and conditions suggested by science teachers in middle schools to improve it. A quantitative approach using a questionnaire was applied to evaluate science teachers' beliefs and practice of the pedagogical components of meaningful learning (PCML). In addition, a qualitative approach using a semi-structured interview with open-ended questions was applied to identify obstacles and conditions that might affect the implementation of ML in science teaching in middle schools.

Findings suggest that science teachers hold high positive beliefs towards (ML) and its various components. The research results also indicate that, in general, science teachers in middle schools tend to practice the PCML. The findings show a general strong positive relationship between the beliefs and the practice of PCML. The findings also imply that there are statistically significant differences between the mean values of the practice of *knowledge construction* (KC) and the *learning based on teaching* (LBT) components, attributed to teachers' gender in favor of females compared to males. A significant difference between the mean values of the practice of *relevance* (R) and the *feedback* (FB) components, attributed to the type of school in favor of state schools compared to private schools, is noted as well. Gender and type of schools were found to be influential factors on teachers' practice.

Three kinds of conditions were examined for enhancing ML: pedagogical, administrative and student associated. Following an analysis of the contents of the *pedagogical condition*s for enhancing ML, five themes (conditions) emerge from the responses of participants: application of digital tools, exercising various teaching and assessment methods, assessment for learning, implementation of constructive learning principles and differentiated instruction. In regard to the *administrative conditions*, six themes were identified as follows: resources, principal support, teacher professional development, curriculum, autonomy and flexibility of the teacher role and professional team collaboration. The *conditions related to student* included: students' motivation, open mind and responsibility, awareness of the importance of sciences to real and future life, previous knowledge, various basic skills and normal personal and socioeconomic background. *Teacher-student relationship* is another important condition suggested by science teachers to enhance ML in middle schools.

This study also aims to expose the obstacles that hinder the enhancement of promoting ML in science teaching. Five themes emerge from the responses of participants: teachers' beliefs, lack of professional qualification**,** educational workload**,** high class size and students' personal characteristics.

The study recommends that when decision makers in the Israeli educational system attempt to improve the implementation of meaningful learning it is essential they take into consideration the conditions and the obstacles suggested by science teachers, especially in light of science teachers' report of positive beliefs and practice regarding teaching that may promote meaningful learning. It also recommends to provide additional hours for teaching science in private schools to allow a comprehensive practice of meaningful learning dependent on time and effort.

**Keywords:** Meaningful Learning (ML), Science Teachers, Middle Schools, Beliefs and Teaching Practice, Pedagogical Components of Meaningful Learning (PCML).

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## ACRONYMS AND ABBREVIATIONS

**R –** Relevance

**KC-** Knowledge Construction

**CT-** Critical Thinking

**FB-** Feedback

**LBD-** Learning by Doing

**LBT-** Learning Based on Teaching

**ML** - Meaningful Learning

**PCML** – Pedagogical Components of Meaningful Learning

# INTRODUCTION

**Background of Study.** Numerous reports have been written about the need for more effective teaching and learning approaches that focus on the demands of life and work in the 21st century, as current places of work require more proficiency, competence and professionalism. Employees must be able to communicate, collaborate and research ideas, collect, synthesize, and analyze information. They need to develop new products and be able to apply different areas of knowledge to new problems and challenges (Barron & Darling-Hammond, 2008). Our world is characterized by the availability of huge amounts of information, technological developments, a rapidly changing socio-culture, family structures and people's beliefs as reflected in the desire to be involved in their communities and society at a large scale (Israel, Ministry of Education, 2014). These transformations require those in charge of educating youth to seek new and different ways to prepare students for the changing world (McTighe, 2014) while focusing on helping them master how to study in meaningful learning processes, so that they can manage the demands of these changes (Barron & Darling-Hammond, 2008).

The teaching of science in schools is also undergoing a process of change in an attempt to facilitate the acclimatization to these transformations and their impact on our lives (Schwartz & Stern, 2014). Performance and demands for a technologically and scientifically literate workforce prompt calls for reform, particularly in the area of curriculum and instruction (Levin, 2012; Liu, 2009).

Consequently, scientific and technological education is perceived as essential for providing the necessary proficiency for every student that will be an adult citizen in the 21st century (Goldschmidt, 2010). Knowledge and scientific thinking are relevant and even vital for problem solving in "real" life, as for the understanding and analysis of information received from different sources (Feinstein, Allen & Jenkin, 2013)**.** Although students do not generally negate the importance and value of science, a majority of them do not choose to take science courses at school due to a lack of interest as they do not see themselves pursuing a scientific career in the future (Loukomies et al., 2013). In addition, students generally feel that science is irrelevant to their everyday lives, especially when the subject under study is complex and abstract (Foster, 2008). As a result, they report boredom and low motivation for learning. According to Hofstein et al. (2011), science is not perceived to be relevant when students are passively engaged in learning, for instance, when students are frequently required to memorize material from science curricula (Hofstein, Eilks, & Bybee, 2011).

In recent years, various Israeli sources have warned that there seems to be a reduction in the Israeli scientific reserve, a growing shortage of skilled manpower to fill high-technological positions in industry and other fields, and an expected lack of scientists and engineers in the near future; furthermore, it has been reported that Israeli students have, relatively, low scientific literacy (Eikan-Mani & Rozan ,2013). Scientific literacy refers to "the ability of students to acquire new knowledge, apply knowledge, explain scientific phenomena, and draw conclusions and skills from their gained information. It also includes their ability to analyze, deduce and explain effectively the ways in which they approach problems, interpret them and find solutions for a variety of situations" (RAMA, 2014). It is customary today to use the term "Imparting scientific literacy" as the goal of teaching science to all citizens (Schwartz & Stern, 2014).

The low literacy in science and technology in Israel is reflected in the results of the PISA tests, carried out by the Organization for Economic Cooperation and Development (OECD) once every three years with the purpose of examining the extent to which students aged 15 are "ready for adult life". The 2015 PISA tests indicated that scientific literacy in Israel ranks below the average of OECD countries and the gaps are large (26 points less than the OECD countries in 2015). Israel's achievements in PISA tests have improved over the years. However, the achievements of the 2015 PISA tests are not significantly different from those obtained in 2012. Israel's rank remained in the same place in the field of science - ranking 40th out of the 70 countries that participated in the study. In addition, the percentage of advanced students is lower than that of the OECD. The percentage of students who have difficulty in science remained relatively high: about 31% in 2015 in Israel in comparison with an average of 21% in the OECD countries (RAMA, 2017a).

The Arab educational system in Israel is an important and inseparable part of the general educational system. It includes the official schools (state schools) and unofficial schools (private schools) under the supervision of the Ministry of Education. The language of instruction in these schools is Arabic (Israel, Central Bureau of Statistics, 2013). The PISA performance in science among students in Arab schools in Israel plummeted between the years 2006 and 2015 as their achievements in 2015 were 92 points lower than the OECD countries; this result indicates a very large gap. The percentage of students who had difficulty in science among Arab students in Israel was 56%, almost three times more than the OECD average (21%). In addition, the advanced levels among Arab students are negligible (RAMA, 2014).

TIMSS test results also reflect the current situation in Arab middle schools. The TIMSS tests aim to assess the knowledge and skills of eighth grade students in mathematics and science. Over the years, the achievements of students in the field of science in Israel in TIMSS tests have improved. However, the 2015 science test results left Israel in the 19th place out of 39 countries, without any significant change in the average achievements in comparison to the 2011 tests. Among students in Arab middle schools, the proportion of those who had difficulties (in the two lowest levels of achievement) in the sciences is more than half (54%) (RAMA, 2017b).

These results call to examine the extent to which science teachers in Arab middle schools offer opportunities for effective learning in their classrooms, or in other words, meaningful learning. According to Gardner (1991), most students, including the best students in the best schools, don't really understand (Gardner, 1991). Students often know far more than they understand about subjects they have studied and suffer from many misconceptions or misunderstandings (Perkins & Unger, 2000). Learning with understanding suggests a much deeper grasp of underlying ideas and concepts, not just the recitation of algorithms or rules. Understanding is knowledge in action, implying that students who understand or learn meaningfully are able to utilize information, concepts, skills, and facts and apply them in new situations where they are appropriate (Earl, 2013). In sciences, students are expected to demonstrate their understanding of the discipline by solving a variety of problems (Michael & Rovick, 1999).

The challenge for educators is to apply the emerging understanding about learning to help students become citizens for a preferred future. Students should learn to access, interpret, and apply information; to develop critical thinking and analysis; solve novel problems; make informed judgment; work independently and in groups and other skills to equip them for life in the 21st century. This kind of learning is referred to as "Learning with understanding" or "Meaningful learning", two terms that have become quite common in the education and educational research literature (Earl, 2013).

Meaningful learning (ML) is universally acknowledged as one of the major goals of science education (Michael & Modell, 2003). It is also perceived as means to promote scientific literacy, essentially the primary objective of the reform in science education (Pellegrino & Hilton, 2012). To this end, the US National Research Committee (NRC) recommended the promotion of meaningful learning by developing learners' functioning in the cognitive, interpersonal and intrapersonal domains. The application of meaningful learning processes enables the individual to transfer what he has learned to new situations and new problems, adapt efficiently to a changing situation, improve academic achievement, increase schooling years and thus be better prepared for success in their adult life (Pellegrino & Hilton, 2012).

Meaningful learning (ML) refers to the state in which the new material under study is related to, or incorporated into existing mental models of material available beforehand (prior knowledge) (Michael & Modell, 2003). When students acquire knowledge and skills in a meaningful manner, they will remember the information for a longer period of time and potentially apply this proficiency to a wide range of new problems or contexts (Novak 2001, Novak & Gowin 2001). Consequently, meaningful learning is generally more productive, because the goal is to retain and retrieve verbatim knowledge when we need to apply it (Ausubel, 1963).

Even though meaningful learning (ML) is recognized as an important educational goal (Mayer, 2002a), the NRC report points out a clear absence of concrete attempt to implement this type of learning . Educational interventions focusing on 21$^{st}$ century functioning and meaningful learning have succeeded so far only at a local level and in a limited manner, as it is difficult to expand to a systematic mechanism for this type of learning. To this end, a big change is required in the preparation and training of teachers in terms of teaching and assessment methods. These include, a profound understanding of thinking processes and learning methods associated with students, the use of flexible teaching strategies, representations of different concepts and varied tasks, questioning and explaining of the student to himself, continuous guidance to the learner and giving feedback and an extensive use of formative assessment (Pellegrino & Hilton, 2012).

The educational system in Israel has known a great number of reforms stemming from social, political and global processes. One of the most recent reforms in the Israeli education system carried out since 2014 is the "National Program for Meaningful Learning". This reform emphasizes the necessity of promoting "Meaningful learning" in the educational system as reflected in this statement: "The educational process is aimed to ensure compliance with the required achievements and to give students a sense of growth, value and competence, success and personal realization, the experience of discovery and response to their curiosity, and to develop them as active people who integrate in society and contribute to it. For achieving these aims, we strive for meaningful learning across the educational sequence" (Israel, Ministry of Education, 2013).

Meaningful learning (ML) is defined by the Israeli Ministry of Education as a process in which the student raises questions, locates sources of information, processes information and creates new knowledge relevant to his personal world and life in the technological age of the 21st century. Consequently, and as defined by the Ministry of Education, meaningful learning is based on three components: value, relevance and involvement. *Value* refers to the importance of the learned content on a personal and global level; *Relevance* means that the student believes that what he has learned addresses his various needs ,intellectually, emotionally socially and physio-motorically; in other words, he is able to apply what he has learned on problem solving on a theoretical level and in everyday life; *Involvement* indicates learners' engagement in the learning process based on curiosity, motivation and internal investment (Israel, Ministry of Education, 2013).

According to the Israeli educational system policy, focusing on development of learners' functioning in the 21st century is another aspect that teachers should take into consideration as they aim to promote meaningful learning and it associated with the constructivist approach. The constructivist approach assumes that knowledge is not transmitted to a person, but rather structured in his mind in unique patterns found in consciousness. It has been found that, learners' functioning relates to the following domains: the cognitive, metacognitive, intrapersonal, interpersonal, self-regulating learning and sensory-motoric functioning (Israel, Ministry of Education, 2013).

The Israeli educational system has made considerable efforts to promote and expand the meaningful learning program in all the educational institutions, as part of the "Meaningful learning reform". These attempts include professional development, tutorship, forums, organizational regulations and several policy documents that clarify the goals and means for promoting meaningful learning (Israel, Ministry of Education, 2013). The professional development strategies for teachers aim to expand their awareness and knowledge of the meaningful learning pedagogy, create positive attitudes towards it and suggest ways to implement the pedagogical processes that may help them enhance and implement meaningful learning in their classrooms.

Aiming to evaluate the status of the meaningful learning reform in Israel, the National Authority for Measurement and Evaluation in Education (RAMA) published three reports during the course of 2014- 2017 (RAMA, 2018). The reports disclosed the results of an evaluation research which had been conducted on students, teachers and principals, both in Jewish and Arab Israeli schools, at all age levels. They also provided information about teachers' perceptions and attitudes regarding components of meaningful learning and teaching from all disciplines, evaluating their level of implementation. The results suggest that there is no significant change in teacher and student reporting in regard to meaningful learning between the years 2014-2017.

Research results suggest that despite the awareness of teachers in all age layers, regarding the meaningful learning reform, and the positive attitudes towards its continuation of implementation, it seems that the manner in which teachers perceive and understand the concept of this strategy and its components might play as a barrier to the assimilation of the program. The teachers referred far more to the upper layers of meaningful learning such as diversity in teaching and assessment methods, rather than to the in depth components (relevance, value, engagement) and the quality of the teaching-learning-assessment processes (RAMA, 2018).

It is important to mention that the previous reports published by RAMA concerning the evaluation of the meaningful learning reform did not focus on a specific discipline such as science; the data collected was related to the teachers as a whole in all disciplines, thus, it is essential to assess the status of meaningful learning in science teaching in light of this reform.

**Rationale of the Study.** The reform of meaningful learning highlights the in depth understanding and learning that engage the learner, stimulate the interest and motivation to learn and deliver, over time, better achievements for individuals and society (Israel, Ministry of Education, 2014). Thus, it may be considered a promising strategy to gain better results for teaching science.

This research aims to address the issue of low academic achievements in the realm of science in the Arab middle schools in Israel, as demonstrated in recent PISA tests. In this regard, the literature determines that one of the reasons for this outcome is the negative attitude toward science as it is taught in school (Collins, et al., 2003). Rukavina et al. (2012) asserts that there is a strong relationship between the attitudes towards science and the way in which they are taught (Rukavina et al., 2012). The teaching strategy and the material under study have an impact on their understanding, interest or motivation, in learning (Weizman, 2013). These findings are supported by another study showing that students believe that sometimes science is taught in a manner that fails to capture their interest (Hofstein, et al., 2011).

Studies carried out to examine the educational systems around the world have found that the most influential factor on student achievement is the quality of teachers (RAND Corporation, 2012). Hattie (2009) supports this finding by pointing out that teachers are among the most significant agents in the process of learning (Hattie, 2009). Furthermore, the Mckinsey report states "It is impossible to improve learning without improving instruction" (Barber, 2007).

Consequently, it seems that teachers could play a main role in the process of promoting meaningful learning in science teaching, both in terms of educational strategies and the extent of opportunities they can offer to achieve this end. Therefore, the major concern of this study is to assess science teachers' beliefs and current practices of pedagogical components of meaningful learning at Arab middle schools in northern Israel; assess obstacles in implementing this kind of learning and offer conditions to improve its implementation at these schools. With better understanding of this issue we could be able to design better teaching- learning processes that boost motivation and stimulate deep understanding of science and thus raise students' achievements.

**Statement of the Research Problem.** The meaningful learning reform is currently at the heart of an intensive debate within the Israeli educational system**.** The ministry of education has made considerable efforts on both theoretical and practical levels to promote meaningful learning at all schools in all levels of age and in all disciplines including science and technology.

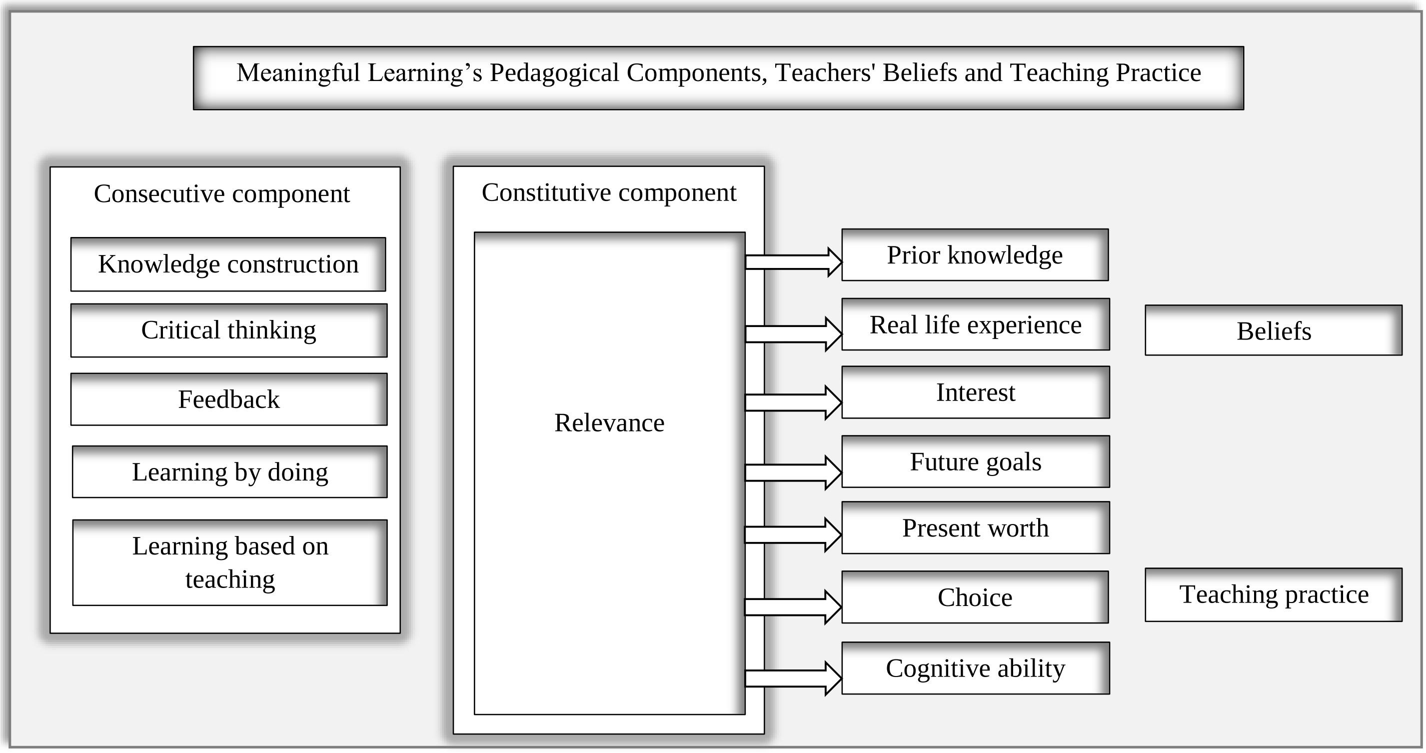
Scientific and technological education is perceived as essential for providing knowledge and skills that are necessary for every student that will be an adult citizen in the 21st century (Goldschmidt, 2010). The curriculum of science and technology in Israel has defined specific pedagogical components to facilitate the implementation of meaningful learning (Israel, Ministry of Education, 2018).

The low results in the international tests in science in Arab middle schools prompt call to assess the level of the actual practices of these pedagogical components in light of the current reform. Thus, it can be assumed that the pedagogical processes of science teaching in Arab middle schools leads mostly to rote learning that is characterized by memorizing facts. This learning strategy inhibits the development of high order thinking skills in sufficient scale, as knowledge does not become internalized and deeply understood. As a result, students are unable to assimilate the new information and apply it to an existing framework. The result is no transferred knowledge or skills between topics or contexts. Therefore, the assumption in this study is that meaningful learning does not take place in these schools as often as it should.

Science teachers in schools in general have been treated in the research as competent judges. They have enough experience, knowledge and skills to assess their teaching. Consequently, the current study focuses on science teachers' points of view regarding meaningful learning in science teaching. So far, there is no published evaluation that has assessed science teachers' beliefs and the extent of practice of specific pedagogical components crucial for implementation of meaningful learning in the Arab middle schools in northern Israel. Therefore, it is essential to examine the beliefs and practices of these components among science teachers in 2019, five years following the implementation of the meaningful learning policy. The study also aims to estimate the correlations between the beliefs and the practice of these components. The researcher also intends to explore background factors, such as gender, years of teaching, educational qualification and school type, to determine whether they have certain effects on teachers' implementation and promotion of meaningful learning. Moreover, the study attempts to identify the obstacles impeding the implementation of meaningful learning, and suggest the basic conditions required for improving the implementation of meaningful learning in the science teaching.

**Conceptual Framework of the Study.** Constructivism as a learning theory offers a framework to make learning meaningful. The conceptual framework for the quantitative part of this study is derived from the literature concerning meaningful learning based on the constructivist paradigm. Based on the pertinent literature, two sets of pedagogical components of meaningful learning (PCML) were identified: *Constitutive* and *Consecutive* components. Each of these components includes the relevant elements described in figure 1, which were identified in early preliminary research conducted prior to this study (refer Appendix E) and also were defined by the policy of the Israeli Ministry of Education as crucial components for generating meaningful learning in science teaching. Consequently, these components form the conceptual framework for this study in the context of teachers' beliefs and practice of these components.

**Figure 1**: The Theoretical Structure of the Proposed Framework



The *constitutive* component of meaningful learning in this study describes the relevance of the topic or the learning activity under study to the student. *Relevance* is one of the guiding principles for a constructivist teaching environment (Taylor et al., 1997) as well as one of the key terms associated with reforms in the teaching and learning of science. In this study and according to the Keller model (1983), *Relevance* was presented as connections of the topic or learning activity to the following elements associated to students': prior knowledge, interest, real life experience (authenticity), choice, present worth, future goals (utility value) and cognitive ability. These elements are internal aspects related to the student and constitute a foundation for creating meaningful learning. Associating the learning process to these elements enhances the relevance of the material under study or the learning activity in the eyes of the student.

Studies show that meaningful learning occurs when students are motivated to invest efforts in learning (Pellegrino & Hilton, 2012). Motivation to learn as emphasized by the first condition set by Ausubel (1968) is the crucial condition for meaningful occurrence. When students are motivated to learn, they try harder to understand the material and thereby learn more deeply, resulting in a better ability to transfer what they have learned to new situations, and thus practice meaningful learning (Mayer, 2002b). Keller (1983) presents a teaching model, which includes four steps to improve motivation in the learning process. One explicitly refers to *Relevance*. Keller (1983) suggests strategies as to how to establish *relevance* through learning, by connecting it to the elements mentioned above. Consequently, *relevance* has been selected to be one of the crucial components of meaningful learning in this study.

The *consecutive* component of meaningful learning in this study describes the activities that should be addressed by the teacher to engage students in meaningful learning. These activities are divided into five elements and detailed as follows: *knowledge construction*, *critical thinking*, *feedback*, *learning by doing, and learning based on teaching.* These pedagogical activities satisfy the second condition of meaningful learning occurring based on the Ausubel theory maintaining that "Teachers should organize the learning activity in a way that allows connecting the meaningful material to the learner’s prior knowledge" (Bretz, 2001). According to the constructivist approach the learners should play an active role in the learning activities to achieve deeper understanding. Active learning means that "learners are engaged in the learning process in a mindful processing of information, where they are responsible for the result" (Jonassen, 1995). Students’ active involvement in constructing their own ideas is suggested to promote meaningful learning (Frymier & Shulman, 1995). Studies have shown a positive impact on learning when students participate in lessons that require them to construct and organize knowledge, consider alternatives, engage in research, inquiry, writing, and analysis, and communicate effectively (Newmann, 1996). Hence, the *consecutive* component of meaningful learning allows students to be involved in the learning process. The elements of this component will be explained in more details later in chapter III. This study assesses the science teachers' beliefs and practice in relation to these components.

**Purpose of the Study**. The purpose of this study is to evaluate science teachers' point of view regarding "Meaningful learning" (ML) in science teaching in Arab middle schools in northern Israel (Galilee and Haifa district). To achieve the main purpose, specific objectives of the study are formulated:

1. To assess science teachers' beliefs and practice of specific pedagogical components of meaningful learning such as: relevance, knowledge construction, critical thinking, learning by doing, learning based on teaching and feedback;
2. To assess the correlations between science teachers' beliefs and their practice of those components;
3. To assess the correlations between specific background variables of science teachers such as gender, educational qualifications, years of teaching experience, school type (sector) and their practice of the pedagogical components of meaningful learning;
4. To identify conditions that should be provided to enhance meaningful learning in science teaching, according to science teachers' opinion;
5. To identify obstacles that science teachers face in implementing the meaningful learning in science teaching, according to science teachers' opinion.

**Significance of the Study.** This study addresses the meaningful learning reform that since 2014, has become the focus of an intensive debate in the Israeli educational system**.** The purpose of meaningful learning, is to improve science-teaching outcomes by making the learning process more relevant and meaningful to the students. The knowledge to be gained in this study is designed to improve future reform efforts in science education.

From the theoretical point of view, the significance of the study is as follows:

1. This research will provide a more complete picture of the beliefs and practice of science teachers regarding pedagogical components of meaningful learning.
2. This study may provide insights for teachers in other fields as well, to be aware of the need to make changes in their beliefs and practice in regard to their teaching.
3. This study will contribute to the literature on science education by filling a gap regarding the conditions and factors affecting the promotion of meaningful learning in science teaching.

From the practical point of view**,** the significance of the study is as follows:

1. The research instrument could be utilized by science teachers as a reflective evaluation tool to gather information about their thinking and practice, thereby serving as valuable input to improve their teaching outcomes and design instruction to promote meaningful learning.
2. The Israeli ministry of education is making efforts to expand the implementation of meaningful learning at schools. Therefore, these findings will provide information which could help decision makers to review the work on this issue in an extensive and more effective range.

**Limitations of the Study.** There are four primary limitations to this study. First, this study investigates science teachers' perceptions of conditions and obstacles that may affect the promoting of meaningful learning and assesses their beliefs and practices of specific components of meaningful learning in Arab middle schools in northern Israel. Because science teachers have their own distinct perceptions, experience, and patterns of thinking, the manner in which they are reflected may be different from teachers of other disciplines. Therefore, it is possible that generalization and transferability of this study will be limited to science teachers. Secondly, this study will include science teachers only in the Galilee and Haifa district Arab schools in Israel and not in all Arab schools. However, given that nearly 80% of Arabs in Israel live in the Galilee and the Haifa district, this study will cover a good portion of them. Thirdly, this study treats only some of the pedagogical components of meaningful learning, and does not cover all of them, due to the broad aspects of this topic. Fourthly, no further interviews or observations were conducted in addition to the quantitative instrument to examine science teachers' actual practices of the pedagogical components of meaningful learning. It is also essential to examine in depth the quality of the practice (how to apply) and their impact on students' understanding and learning.

**Definitions of Terms**

*Constructivism*- constructivism is a theory of learning or meaning-making, that offers an explanation of the nature of knowledge and how human beings learn. It argues that individuals create or construct their own new understanding or knowledge on the basis of an interaction between what they already know and believe, and the ideas, events, and activities they come in contact with (Richardson, 1997).

*Student activity*- students engage in learning activity comprising three dimensions: behavioral (physical), cognitive and emotional (Fredricks et al., 2004).

*Relevance*- the term *"relevance"* typically refers to learning experiences that are either directly applicable to the personal aspirations, interests, or cultural experiences of students or that are connected in some way to real-world issues, problems, and contexts outside of school (Glossary of Education Reform, 2013).

*Prior knowledge*- students' prior ideas and conceptions relating to events and phenomena in the world around them, which might well be the same or different from those intended by the teacher and the scientific community.

*Authenticity*- learning materials and activities are framed around "real life" contexts in which they would be used (Herold, 2002).

*Understanding*- students are said to understand when they are able to construct meaning from instructional messages and build connections between newly gained and prior knowledge (Mayer, 2002b).

*Meaning construction*- refers to a process during which new regularity is perceived in events or objects, or records of events or objects, leading to concept formation and/or the construction of new propositions (Novak, 2002).

*Meaningful learning*- meaningful learning is non-arbitrary, non-verbatim, substantive incorporation of new ideas into a hierarchically arranged framework in cognitive structure. The learner relates new information or ideas to relevant aspects of their current knowledge structure in a conscious manner (Ausubel, 1963).

*Rote learning*- rote learning refers to an arbitrary, verbatim, non-substantive incorporation of new ideas into a cognitive structure, but with no specific relevance to existing concept/propositional framework. Most importantly, rote learning tends to be recalled for only a short period of time and easily forgotten (Ausubel, 1963).

*Critical thinking*- critical thinking refers to a higher thinking order encompassing specific abilities, namely presenting and assessing arguments, claims, or evidence; making inferences; judging or evaluating (Ennis, 1985; Facione, 1990).

*Learning based on teaching* - also known as peer tutoring or peer instruction, refers to a teaching and learning approach. The basic idea of "learning based on teaching" is that learners take the role of the teacher for a certain period of time in class. The duration can be a whole lesson or only the time required for a special activity (Hatano and Inagaki, 1991).

*Learning by doing* (or experiential learning) - refers to a learning process deriving from one's own actions and experiences, in contrast to learning from watching others perform, reading others' instructions or descriptions, or listening to others' instructions or lectures (Hayne, 2011).

*Knowledge construction*- refers to knowledge that cannot be transmitted from one individual to another in any mode. Knowledge is actively built by the learner, using high level internal cognitive processes acting on stimuli from the environment (Michael, 2003). Knowledge construction encourages learners to activate prior knowledge and try to connect it to new information (Blumenfeld, 1992).

*Feedback*- refers to information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding (Hattie & Timperley, 2007).

*Beliefs*- The term "beliefs" in this study refers to the perceptions or way of thinking as offered by science teachers towards the main pedagogical components of the meaningful learning.

*Practice*- the term "practice" in this study refers to the actions or behaviors that teachers carry out in the class which align with the components of meaningful learning.

# CHAPTER I

## SIENCE TEACHING IN MIDDLEL SCHOOLS IN ISRAEL

This chapter includes an introduction to middle school education in Israel, science teaching in middle school education and meaningful learning in science teaching.

### 1. Middle School Education in Israel

The Israeli Ministry of Education introduced a comprehensive reform in the education system in 1968, as it transformed a two-stage structure composed of eight years of elementary school and four years of high school to a three-stage structure comprised of elementary school- grades 1-6, middle school - grades 7-9 (ages:12 to 15) as part of the secondary school, and the upper grades (10-12) as part of high school. The structural changes were intended to raise the level of teaching as well as academic and educational achievements in all stages of schooling. In addition, the new reform aimed to increase chances of integrating into society by creating a meeting point for children from diverse population groups in regional education frameworks. Creating the middle schools as a transitional stage was also important in terms of students' psychological and social development. The middle school age group is characterized by particular pedagogical needs identified with adolescence, and therefore requires a unique framework, distinct from both primary and high school age groups (Vorgan, 2010).

The middle school serves as a follow-up and adjustment period for counseling students and parents, as for directing students to continue their post-elementary studies in a direction appropriate to their tendencies and abilities. The implementation of the structural reform has encountered ongoing difficulties since its creation. Over time, three different structures were created (Vorgan, 2010):

1. A six-year elementary school (grades 1-6), a three-year middle school (grades 7-9) and a three-year high school (grades 10-12);
2. A six-year elementary school (grades 1-6) and a six-year secondary school (grades 7-12);
3. An eight-year elementary school (grades 1-8) and a four-year secondary school (grades 9-12).

In the 2007-2008 school year, the "Ofek Hadash" reform was implemented in all official middle schools. The program was designed to promote teaching, learning, academic achievement, and educational climate in the school, both socially and emotionally, and carried out through two main steps:

A. The promotion of education and teaching-learning focuses on the entire school, especially within the framework of individual hours.
B. Strengthening the profession and teaching quality of teaching staff through professional development and allocation of time to perform various tasks in the educational institution, in addition to teaching in the classroom.

Furthermore, the purpose of this reform is to improve teachers' teaching status, integrate high quality teachers, and promote the achievements of the educational system. As part of the reform, a full-time teacher works 5 days a week. The total work week of a teacher in a full time position is 36 weekly hours, all within the school compound, and is detailed as follows: frontal teaching consisting of 23 hours, individual instruction 4 hours and 9 hours of stay, all adding up to a total of 36 hours.

- 23 hours of' frontal teaching performed by the teacher for all students as a whole in the main classroom, in the study group, in the lab, and so on.
- 4 individual hours during which the teacher works with one student or a group of up to 5 students. These hours are intended to deepen the meaningful discourse between the teacher and his students and provide scholastic reinforcement for students.
- 9 hours of stay during which the teacher stays on school ground and engages in the following activities: team work meetings up to 4 hours a week, including pedagogical councils, professional staff with professional coordinator, multi-professional staff, etc. In addition, the teacher is obligated to perform various tasks like checking tests for the rest of the hours of stay (5 hours or more) (Cohen-Orenstien, 2012).

## 2. Science Teaching in Middle School Education in Israel

The curriculum in science and technology in Israel is based on the constructivist theory of learning that fosters the independent learners and allows constructing knowledge in a meaningful learning process, while calling attention to strong and dynamic interactions between teaching, learning and assessment processes (Sella & Dressler, 2007). The current curriculum in science and technology gives expression to different principles like concept acquaintance, phenomena, scientific processes and principles, understanding the meaning of scientific and technological knowledge for the individual and society, as well as fostering thinking skills through experience, inquiry learning and problem solving. All these are essential for a successful graduate in tomorrow's society (Klein, 2011).

In middle schools in Israel, science is integrated into one discipline - "science and technology". This field includes content areas in biology, chemistry, physics and technology. The content areas are organized according to key topics and their sub-topics. The curriculum sets out the skills to be taught alongside the areas of content (Israel, Ministry of Education, 2018).

The science and technology curriculum for middle schools is based on the STS (Science, Technology, Society) approach that combines the fields of science, technology and society altogether.  Science and technology constitute a central part of human culture and our everyday reality, as it is essential to the existence and development of society in the modern world. On these grounds, there is a need to develop scientific and technological literacy for the entire student population in all sectors as part of the general education. This literacy relates to the following aspects: understanding the world around us in terms of science and technology; thinking and motor skills; values, attitudes and behaviors (Israel, Ministry of Education, 2018).

The science and technology curriculum for middle schools aspires to develop scientific-technologically literate and curious citizens who are able to learn independently, and manifest this knowledge in terms of practical skills to understand the phenomena around us. The Ministry of Education goes on to say that students should be able to solve problems, make decisions, ask questions, locate and evaluate sources of information, distinguish between facts and personal opinions, between reliable and unreliable information, be open to new information, recognize that science and technology are the outcome of human thought, are aware of their importance in promoting humanity while recognizing the shortcomings and limitations of these areas, deal successfully with the rapidly changing challenges of reality and become partners in the growth of a flourishing exemplary society. In addition, the curriculum seeks to encourage students' motivation to engage in these fields in the future in order to be part of the community of scientists, engineers, technologists and technicians of the country (Israel, Ministry of Education, 2018).

## 3. Meaningful Learning in Science Teaching

According to the Ministry of Education (Israel, Ministry of Education, 2018), meaningful learning takes place when students learn beyond facts, create links between them, interpret information, think about processes of their understanding, apply new concepts to new situations, activate creative thinking, solve problems, change attitudes and opinions, develop skills and construct knowledge. The Ministry has defined some pedagogical principles in the teaching of science and technology in order to generate meaningful learning. These principles are based on the constructivist paradigm. Constructivism emphasizes the construction of knowledge within social and cultural contexts. The pedagogical principles are based on the following assumptions:

- Learning as *an active* process*:* each learner engages actively in the process of learning in a cognitive, physical, social and emotional manner, to construct a personal meaning.
- Learning as *a constructive* process: the combination of previous knowledge and new knowledge contributes to the construction of a new concept.
- Learning as a *social* process: learning takes place during a social interaction between students and their peers that stimulates internal processes of creating meaning.
- Learning is *authentic*: authentic learning is based on experience in the real world.
- *Feedback from ongoing assessment*: refers to an ongoing process that provides teachers and learners with information on the development of the learning process. A meaningful feedback allows the evaluation of the learning process during and after its occurrence and make decisions about improving both teaching and learning.
- *Implementation of constructivist teaching approaches*: experiential learning (hands-on activities) is one of the cornerstones of science and technology studies, and in essence is the interaction between physical and cognitive activity. Experimental learning is important for constructing knowledge, understanding and skills, as for demonstrating phenomena and processes, clarifying scientific terms and discovery through research.
- *Coping with heterogeneous class learners (differentiated teaching)*: human beings differ in their cognitive structures. A heterogeneous class consists of a complex of

individuals, differing in many characteristics: personality, learning styles, needs and desires, cognitive abilities, ways of thinking, tendencies and habits of thought and other variables. Hence, the role of the teacher is to expose learners' thinking structures (prior knowledge, perceptions, attitudes, behaviors, beliefs, and attitudes) to a variety of appropriate experiences for the active construction of knowledge.

- *Fostering motivation to learn science and technology*: an important condition for the occurrence of meaningful learning is learning from intrinsic interest and motivation. Among the actions that strengthen intrinsic motivation are the following: participation in the choice of determining learning goals and assessment methods, inviting experiences that stimulate interest in the subject under study, clarifying the usefulness of the content under study. Another important factor for creating intrinsic motivation is self-efficacy. Teachers must therefore provide challenging tasks adapted to learners' abilities, as well as constructive feedback manifesting confidence in students' ability.

These pedagogical principles are the core components whose implication in the classroom may improve the teaching-learning process.

# CHAPTER II

# MEANINGFUL LEARNING AS A THEORY AND PRACTICE MODEL FOR TEACHING SCIENCE

This chapter summarizes the research literature relating to meaningful learning. The topics discussed in this chapter are: constructivism as a promising learning theory for science teaching, and meaningful learning as the underlying theme of constructivism, and indicators, conditions and obstacles for meaningful learning occurrence.

## 1. Constructivism as a Promising Learning Theory for Science Teaching

Constructivism refers to the theory of learning or meaning-making, designed to offer an explanation of the nature of knowledge and how human beings learn. It argues that individuals create or construct their own new understandings or knowledge on the basis of an interaction between what they already know and believe and the ideas, events, and activities they come in contact with (Richardson, 1997)**.** The verb *to construct* comes from the Latin *con struere*, which means to arrange or give structure. Ongoing structuring (organizing) processes are the conceptual heart of constructivism (Mahoney, 2003).

Constructivism refers to a learning approach that perceives the individual as an active and responsible agent in his/her knowledge acquisition process (Brooks & Brooks, 1999). Such a process allows learners to actively make sense of the world by constructing meanings (Scott, Dyson & Gater, 1987). According to the constructivist view, learners are engaged in high-level cognitive activities, enabling them to develop new concepts and understandings based on their previous knowledge or preconceptions (Shuell, 1996). It has been shown, particularly in the field of mathematics and science education, that powerful learning environments create the conditions for students to actively construct their own knowledge (de Corte, Greer & Verschaffel, 1996).

Piaget (1972), in his cognitive constructivism approach**,** also known as personal constructivism, argues that knowledge is not a product that can be transferred from one person to another. It is an ongoing process of acquisition through which the learner constructs his own personal knowledge. Piaget refers to this process as "knowledge structures", "mental structures", or "cognitive structures" that emerge from the learner's personal experiences.

Piaget introduced the constructivist concepts of assimilation, accommodation, disequilibration and equilibration in order to describe the mental process that occurs to organize mental structure (Skaalid, 2007). According to Chen (1997), assimilation refers to the learner’s attempt to construct and reconstruct knowledge by connecting it to previously absorbed information or experience. Accommodation, on the other hand, occurs when the learner realizes that the acquired information is not consistent with previous knowledge (Skaalid, 2007). When there is no match between previous understanding and new knowledge, the learner enters a process of disequilibrium during which modification is required (Chen, 1997). This process stimulates learners to revise their notion of behavior of objects.

Having introduced the social perspective of constructivism, Vygotsky (1978) asserts that our understanding of learning is enhanced through a social process such as interaction with other students and teachers. He argued that the capacity to learn from others is fundamental to human intelligence. Learning occurs through participation in various cultural practices and shared learning activities, in addition to individual knowledge formation. Thus, humans construct knowledge when engaged in social activities (Kim, 2001).

Social constructivism stresses the collaborative processes leveraging knowledge construction (Windschitl, 2002). According to Bakhtin (1984), meaning is a product of dialogues: "truth is not born nor is it to be found inside the head of an individual person; it is born between people collectively searching for truth, in the process of their dialogic interaction" (Bakhtin, 1984). A concept that clearly demonstrates the social constructivist view is Vygotsky’s ‘zone of proximal development’. The zone of proximal development refers to “the notion that developing mental functions must be fostered and assessed through collaborative activities in which learners participate in constructive tasks or problem solving, with the assistance of more knowledgeable others” (Windschitl, 2002).

Collaborative or cooperative learning groups are examples of approaches based on social constructivism. Considerable evidence from studies of different "collaborative" learning settings suggests that students working together learn more than those operating independently (Lunetta, 1990). Student interaction designed to solve problems yields a significant increase in learning outcomes. The benefits of cooperative learning are utilized in all science disciplines. Through interpersonal communication, students learn concepts and information associated with different realms, addressing various types of issues in academic and social fields, including self-learning skills (Rousseau, 2000).

John Dewey (1916) laid out a progressive new approach to education already a century ago. Believing that experience is the best education, he created a system that would focus on learning-by-doing. For Dewey, education depended on action. Knowledge and ideas could only derive from experiences that had meaning and value for students (Dewey, 1916). These situations had to occur within a social context, such as a classroom, where students manipulated materials collaboratively and, thus, created a community of learners who constructed their knowledge together.

Dewey believed that a child is an active learner who learns best by doing. He advocated for constructive activities in the classroom that were meaningful and interesting (i.e., connecting with the child's social environment) for children. Education should not be about becoming narrowly educated in academic topics; it should be pragmatic and teach children how to think and adapt to a world outside (Dewey, 1929).

## 2. Meaningful Learning as the Underlying Theme of Constructivism

**Constructivism and Meaningful Learning.** Constructivism as a learning theory offers a framework to make learning meaningful. Constructivism is a theory of meaning-making that offers an explanation on the nature of knowledge and how human beings learn. According to Richardson (1997), constructivism argues that people create or construct their own new understandings or knowledge through interaction with ideas, events, activities (Richardson, 1997).

Ausubel et al. (1978) used the term 'meaningful' to describe the interaction between newly acquired and existing information (Ausubel et al., 1978). This interaction constitutes the 'knowledge building process' that is one of the fundamental principles of constructivism. In contrast, mechanical learning occurs when new information is acquired through memorization, with no integration with previously existing knowledge.

Novak (1977) defined meaningful learning as "the underlying theme of constructivism that integrates thinking, feeling, and acting, leading to human empowerment for commitment and responsibility". Thus, in order to promote meaningful learning, it is necessary to set up a learning system that addresses three domains: cognitive, affective, and psychomotor (Novak, 1977)**.**

**Meaningful Learning Theory.** Learning refers to a change in behavior owing to interaction with the environment (experience) (Michael & Modell, 2003). It is a dynamic process that can be developed through the iterative process of fitting information into patterns or schema of similarities, differences, likeness, and regularities (Earl, 2013). Learning is also defined as a relatively permanent change in understanding based on personal experience. *Permanent* means that learning is long-termed rather than short-termed, as a temporary mindset does not reflect learning. *Change* means that learning involves a cognitive transformation reflected in behavioral change, as if there is no change, there is no learning. *Experience* means that learning depends on the experience of the learner. It depends on how the learner interprets what happens- that is, it depends on the learners' personal experience (Mayer, 2002b).
Viktor Frankl (1997) defines "meaning" as an interpretation, explanation and value. According to Frankel a sense of meaning is a necessary existential need to humans (Frankel, 1997). The significance of meaning making is reflected in this statement: "The most powerful human motive is striving for meaning" (Azolai in Herpaz, 2014a).

Meaning making involves a new regularity in records of events or objects, leading to concept formation and/or the construction of new propositions. As we learn new concepts and propositions, we understand their meaning as well as the relationships between them. Knowledge is stored in our brain as a network of concepts and propositions. As meaningful learning proceeds, new concept meaning is integrated into our cognitive structure to a greater or lesser extent, depending on how much effort we make to seek this integration, and on the quantity and quality of our existing, relevant cognitive structure (Novak, 2002). Vygotsky (1962) suggested that construction of new meaning takes place in a "zone of proximal development", or that area of cognitive structure that is prepared to accept new altered ideas (Vygotsky, 1962).

Many definitions have been given by educational thinkers to the concept of "Meaningful learning". According to Carl Rogers (1969), learning with meaning is more than collecting facts. It is a learning that makes change in the individual behavior, in terms of attitudes, personality, and the direction of the activity he will choose in the future.

In his book "The Freedom to Learn", Carl Rogers (1973) examined meaningful learning versus rote learning. Meaningful learning is defined as an experiential process, as opposed to rote learning that focuses on memorizing facts, easily compressed in individuals' brain to which the learner does not attach any importance. According to Rogers (1973), meaningful learning occurs when a student appreciates the relevance of the material under study, and its contribution to his development. The elements that construct meaningful learning, according to Rogers are: personal involvement, the initiative is put in the hands of the learner, and the learner himself makes the assessment of his own achievements.

In his cognitive assimilation theory, Ausubel (1963) defines meaningful learning as non-arbitrary, non-verbatim, and substantive incorporation of new ideas into learner's cognitive structure. According to Ausubel (1963), meaningful learning prompts the integration of new concepts and propositions into a hierarchically arranged framework in a cognitive structure. Knowledge deriving from meaningful learning is integrated into learner's consciousness as it relates to existing information. It is unique to the learner because it is constructed on the basis of existing elements in his mind (Ausubel, 1963).

Darling-Hammond and others (2008) emphasized the cognitive aspects of meaningful learning. Contending that meaningful learning takes place when one learns beyond memorizing facts, they go on to say that it serves as a tool for the interpretation of information, as it creates a relationship between facts, regulates understanding, allows the implementation of new concepts in new situations, uses creative thinking, solves problems, feels change in approaches and thoughts, develops skills and construct knowledge (Darling-Hammond et al., 2008).

Herpaz (2014b) defined meaningful learning as a "process whereby a person attributes value and interest in the learned contents and invests in constructing them". In addition, it refers to how learners reorganize their experiences (knowledge, concepts, thoughts and emotions) and create a foundation for more complex experiences in the future (Herpaz, 2014b) . Avni and Rotem (2013) state that learning becomes meaningful when it is important, valuable and meaningful for the learner's conceptual world, emotion and cognition. According to Solomon (2014), meaningful learning involves a personal interest as it is the product of understanding and the creation of contexts and relationships that are important to the learner (Solomon, 2014). According to Johannsen et al. (2012), meaningful learning is an active process whereby newly acquired knowledge is interpreted against past knowledge, thereby fostering greater and more in-depth understanding (Johannsen et al., 2012).

As described in the various definitions, meaningful learning focuses on active learning that engage learners to construct their own knowledge and understanding regarding contexts that are relevant and valuable for them. This kind of learning includes various aspects such as cognitive and affective aspects.

**Practice of Meaningful Learning.** Previous studies have indicated that it is essential to develop and accept different approaches for teaching science in order to enhance students' interest and ability in this field (Karsai & Kampis, 2010). This section details the proposed methods designed to promote meaningful learning.

*Graphic organizers and concept maps:* one of Ausubel's (1968) propositions in the epigraph of his book: "Ascertain what the learner knows and teach him accordingly" (Ausubel, 1968). According to this statement, Ausubel offered the graphic organizers as a tool that can help to achieve both of these objectives. Graphic organizers can assist establish existing information as well as help organize instruction that builds upon and extends that knowledge. They could also facilitate meaningful learning by reducing common barriers to teaching and learning for meaning (Trowbridge & Wandersee, 1998). The concept map is a type of graphic organizer which was first constructed by Novak. Concept map is a schematic device that can be used to represent a set of concepts and meanings integrated in a framework of propositions (Novak & Gowin, 1984). Concept maps have been successfully used by tutors and facilitators in many disciplines, particularly in science, to promote meaningful learning and effective teaching.

*Learning through technology:* Ashburn & Flodden (2006), emphasized in their book "Meaningful Learning with Technology", that technology functions for learners as an intellectual partner that helps them promote thinking, learning and understanding of the world in which we live. Learning with technology will promote meaningful learning if it is based on learners' involvement in the construction of knowledge; whether through conversation, self-expression or reflective thinking. Learning techniques also include inquiry, design, communication, writing and visualization.

*Project-based and product-based learning* are all represented by the abbreviation "PBL". Their sources stem from the progressive education introduced by John Dewy who proposed to make learning relevant for learners by connecting the material to their own experience, to their subjects of interest and to their social needs. These educational approaches help to construct meaning according to the constructivist learning approach advocated by Piaget, Vygotsky and others (Israel, Ministry of Education, 2015).

*Learning through inquiry*: another teaching method presented as a promoter of meaningful learning is learning through inquiry. This concept was first introduced in the field of education by Dewy, who explained that inquiry is a "process whereby the undefined and unknown becomes in a directed and intentional way a clear unified wholeness". In education, the term "inquiry" is considered a super-concept from which stems a "family" of educational approaches: learning through inquiry, project based learning and problems based learning.

All of the mentioned approaches put the student in the center of the learning process and encourage meaningful learning processes, characterized by knowledge constructing through searching solutions to problems or questions (Loyens & Rikers, 2011). However, Ausubel postulates: "The mixing of distinctions led, in part, to the expansion of the mistaken assumption that reception of learning is always mechanical (rote) and that learning in the way of discovery is always meaningful. In fact, all of them may lead to rote or meaningful learning, depending on the conditions in which learning takes place". According to Ausubel, it is possible to assume that meaningful learning can happen in different ways. In other words, the teaching method does not necessarily indicate the extent to which meaningful learning occurs. It will not be effective if it is applied in random and an unorganized manner (Yehieli, 2007).

**Meaningful Learning as learning with Understanding.** Meaningful learning has been proposed as a learning approach with in depth understanding (Michael, 2001). Bransford et al. (2000) highlight the importance of understanding in this statement: "Transfer is affected by the degree to which people learn with understanding rather than merely memorize sets of facts or follow a fixed set of procedures". This has been also supported by Pellegrino (2006), arguing that: "Students must have opportunities to learn the subject matter with deep understanding rather than memorizing factual content. A deep understanding of subject matter allows transforming factual information into usable knowledge". Perkins (1993) advocates the need for teaching with understanding: "We must teach for understanding in order to realize the long-term payoffs of education".

Jay McTighe (2014) also emphasized that to prepare our students for a 21st Century world, education today must help students go beyond memorizing science facts and develop deeper understanding of the world around them and the global society in which they live. Students need to learn how to find, sort, evaluate and apply information to new situations. They need to learn how to ask critical questions and solve difficult problems (McTighe, 2014).

Individuals with surface understanding handle learning units separately, have difficulty making sense out of new information and focus on recalling/memorizing rather than understanding knowledge. For in depth learners, on the other hand, learning is associated with searching for evidence, establishing connections, making meaning and employing higher order thinking skills (Entwistle, 2005).

Teaching ought to help students move toward high levels of meaningful learning, especially in receptive instruction that is the most common (Novak, 1993). Herpaz (2014c) argues that the most basic principle of teaching enabling meaningful learning is using various models of "Teaching for understanding" like those which developed by Whiskey (2004), Wiggins and MacTighe (2013) and others. Meaningful learning involves understanding information (concepts, processes, procedures, values), potentially realized by indirect instruction whereby the teacher encourages students to engage in processing, criticizing and creating knowledge. (Herpaz, 2014c).

Since understanding is a concept associated with internal cognitive processes, and because it is impossible to penetrate into one's consciousness to see if it is indeed an integral part of one’s cognitive structure, psychology and education employ indirect methods to examine the extent to which learning is meaningful (Yehieli, 2007). One of the fruitful ideas in this context is the Perkin approach in regard to "Understanding performances" (Perkins, 1997). The idea is to test meaningful learning or understanding, (according to Perkins), by asking the student (verbally or in writing) to carry out an action that has not been performed yet: to illustrate the concept, to explain it in other words, to create a metaphor, to build a model, to ask a question, to justify and produce evidence, to formulate contradictory knowledge, to predict possible outcomes , to break down knowledge into units (analysis), to compose pieces of knowledge into one unit (synthesis), etc...(Yehieli, 2007)

**Meaningful Learning versus Rote Learning.** Meaningful learning is often contrasted with rote learning. Meaningful learning involves the integration of new concepts and propositions into a hierarchically arranged cognitive structure (Ausubel, 1963). Evidence suggests that meaningful learning is associated with a rich network of links or connections between new and existing knowledge. In this case, the learner is likely to possess multiple representations of the knowledge and skills obtained, and she or he has the ability to pick the model that most usefully supports the problem solving process being exercised (Michael, 2003). When students acquire knowledge and skills in a meaningful manner, they will remember the information for a longer period of time and be able to apply it to a wide range of new problems or contexts (Novak 2001, Novak & Gowin 2001). For these reasons, meaningful learning is generally more productive, unless the goal is to retain and retrieve verbatim knowledge (Ausubel, 1963).

In contrast, rote learning information is incorporated into a cognitive structure, but with no specific relevance to existing concept/propositional frameworks. According to Ausubel (1963), students who learn by rote learning tend to gather isolated propositions in a cognitive structure rather than develop the strongly hierarchical framework of successively more inclusive concepts that are characteristic of meaningful learning. The major limitations imposed by such isolated propositions (in rote learning) are poor retention and poor retrieval of new ideas, potential interference in subsequent learning of related concepts, and inability to use acquired knowledge to solve new problems (Ausubel, 1963).

Rote learning entails that new knowledge is gained simply through memorization, having no integration with existing knowledge and therefore difficult to apply in practice (Cosentino, 2002). Memorizing facts leads students to wrongly believe that they have fully understood the content and that they are able to apply them to all different contexts of practices (Peters 2000). Rote learning ("Memorizing") of knowledge is a common component of all school-based learning. It is generally agreed; that rote learning is a low-level cognitive process that can only provide information ("facts") that may or may not be used later for higher levels of learning.

The goal is to help students accomplish meaningful learning whereby facts are accumulated and organized into a conceptual framework, or a mental model, in a manner they could be utilized to accomplish tasks in the real world (Michael, 2003).

### 3. Indicators, Conditions and Obstacles for Meaningful Learning Occurrence

**Indicators for Meaningful Learning.** Meaningful learning is characterized by retention and transfer. According to Mayer and Wittorock (1996) promoting transfer and retention are two fundamental goals of education. Retention is the ability to remember material at some later time in much the same way it was presented during instruction. Transfer is the ability to use (apply) material learned (knowledge and skills) to solve new problems in new contexts, answer new questions, or facilitate learning a new subject matter (Mayer & Wittorock, 1996). Teaching for transfer occurs when learners are encouraged to select relevant material, organize it into coherent mental structures, and integrate it with existing knowledge (Mayer, 2002b). In meaningful learning both retention and transfer of knowledge are facilitated by building abundant interconnections (links) between existing knowledge structures and newly gained information (Michael, 2003).

Mayer (2002b) pointed out that successfully performed retention and transfer is an indicator of meaningful learning occurrence. In contrast, successful performance of retention but not of transfer, signifies rote learning occurrence (Mayer, 2002b), as transfer is the indicator for meaningful learning occurrence. As meaningful learning is a prerequisite for transfer, students should be involved in the learning process and given opportunities to implement knowledge in different contexts (Fortus, 2002). Transfer is considered one of the understanding performances. Other understanding performances include mental activities, exposing learners' orientation towards the subject under study, and their ability to build upon it (Herpaz, 2000). The transfer is a significant factor in understanding. A successful transfer will take place within the framework of meaningful learning when the student is capable of making the particular subject relevant to his daily life, thereby giving it legitimacy and justifying the learning process (Gilbert et al., 2010).

Mayer (2009) argues that in order to develop strategies designed to achieve effective transfer and other mental activities, five major issues must be considered: what to learn, how to learn, where to measure, when to study and how much time to learn. Using representations of concepts and many different tasks is another way to promote transfer. Mayer (2009) found that attaching diagrams or animation to a text may improve learning and transfer (Mayer, 2009).

**Conditions for Meaningful Learning.** Ausubel (1963) asserts that for meaningful learning to take place, three conditions must be met. First, the learner must choose to relate the new information to his/her cognitive structure in a non-verbatim, substantive fashion; secondly, the learner must possess relevant concepts and propositions that can serve to anchor the new learning and assimilate new ideas; thirdly, the material to be learned must itself have potential meaning. If any of these three elements is lacking, meaningful learning cannot occur.

However, Herpaz (2014c) defines two types of conditions to allow meaningful learning to occur: internal and external. Internal conditions refer to states of consciousness that enable meaningful learning; external conditions refer to features of the environment that enable and encourage internal conditions to achieve meaningful learning. Internal conditions relate first to "student's task involvement" (intrinsically motivated), which defines it as *a process of meaningful learning*; second, they relate to "students' understanding", which defines it as a *product of meaningful learning* (Herpaz, 2014c). According to Herpaz (2014c), regarding the first condition based on the "theory of self-regulated learning" (Edward Desi and Richard Ryan, 2000), intrinsic motivation for involvement in learning activity occurs when a person performs an action which causes him/her pleasure and /or because it attaches value for him/her. This can only occur by filling five basic needs: connection, belonging, sense of competence, freedom and purpose. In other words, both the *involvement* of the student in the learning activity (task) and gaining *understanding* in this activity are essential for achieving meaningful learning. When a person is involved in any task but does not acquire understanding, then learning is not meaningful (Herpaz, 2014c).

The external conditions that Herpaz (2014c) suggests to promote meaningful learning relate to the educational environment that increases a situation of "involvement in the learning process that produces understanding". These external conditions include curriculum, teacher, teaching patterns, method of assessments and organization of students. Herpaz described these conditions as follows (Herpaz, 2014c):

*Curriculum:* the curriculum should be of authentic interest to students. The most basic principle of the curriculum that enables meaningful learning is to replace the topic with a meaningful one (Herpaz, 2012). In addition, the curriculum should avoid these obstacles: the topics organize knowledge in a manner that does not support meaningful learning; the topics are separated and not related to context; transmitting knowledge in an authoritative manner; encourage memorization to prepare for exams (Carmon, 2010).

*Teaching pattern*s: the most basic principle of teaching designed to enable meaningful learning is indirect teaching, a methodology that strengthens intrinsic motivation for learning. Direct teaching refers to a procedure according to which the teacher transmits knowledge to the students; Indirect instruction occurs when the teacher encourages students to engage in the process, criticize, and create knowledge. An active engagement of knowledge construction creates understanding; in other words, connections between concepts and the world of the learner.

*Assessment method*s: the most basic principle of assessment designed to allow meaningful learning is *rich, continuous,* and *mediate* feedback. *Rich* - giving the student detailed information about his achievements and failures; *continuous* - carried out throughout the whole learning process (not just in exams), mediates - also emerges from the output (academic research, art work, film production, etc.) that student produces (and not just from the teacher's direct assessment).

*Organizing* student's *learning*: the most basic principle to support meaningful learning is to give choice. School should allow a broad array of alternatives. Based on the insight that people give meaning to knowledge and creativity by choosing it, the choice in itself is meaningful. School needs to offer diverse areas of meaning and enable the act of selection.

*Physical structure and equipment*: schools are physical environments that do not invite students to stay, certainly not for meaningful learning. New standards must be created for educational institutions and their equipment. Educators also pin high hopes on digital means.

In conclusion, promotion of meaningful learning is influenced by various conditions. The more relevant conditions we provide for encouraging meaningful learning, the more likely it is to occur. Herpaz (2014c) asserts "We have to get out from the trap of all or nothing" or "meaningful or rote learning" as a matter of measure. The product of the learning process is somewhere on the continuum between meaningful learning and meaningless learning (Herpaz, 2014c).

**Obstacles for Meaningful Learning.** Obstacles have been defined in the literature as barriers for meaningful learning. Yehieli (2007) presents four obstacles to the implementation of meaningful learning:

*The size of the class*- this aspect makes it difficult for meaningful learning to meet the first condition of Ausubel. If the teachers understand that they have to direct themselves to the students' cognitive structure, the more students there are the more difficult to succeed in their mission to achieve meaningful learning.

*Covering the learning material* (internal or external pressure)- when teachers are obligated to cover all the material they are more likely to lecture the contents, making it more difficult for them to encourage meaningful learning.

*Egocentricity of teachers* - one of the characteristics of human beings in everyday situations, especially in educational situations, is their being egocentric. Anyone who understands a certain concept or content will find it very difficult to comprehend why the concept or content is not understood and clear to others. This is the case when teachers come to class to teach new content to their students.

*Not all students are directed towards meaningful learning* - this is another obstacle facing teachers who try to make meaningful learning, especially in frontal teaching. If we examine the characteristics of students in the classroom, as individuals and as part of a group of learners, we will note that students are not always motivated and directed towards meaningful learning, even if teachers are. Teachers spend considerable time and effort to encourage students to learn. Frontal teaching makes it difficult, as do other methods such as inquiry and discovery. In all methods, for example, there may be a situation in which students may not understand the concept or the learning content and yet will not ask a question for various reasons. The reason may be attributed to being afraid of appearing weak or bothersome, or maybe embarrassed for being the only ones who do not understand the subject, or perhaps because the material is not included in the exam and thus will not be tested. These circumstances may cause teachers to teach in a non-meaningful manner.

# CHAPTER III

## THE PEDAGOGICAL COMPONENTS OF MEANINGFUL LEARNING IN THE CONTEXT OF TEACHERS' BELIEFS AND PRACTICE

The literature review in this chapter includes two different areas. Firstly, the researcher reviews pedagogical components and discusses their importance for fostering meaningful learning. Secondly, he reviews studies of teachers' beliefs and practice in general and the relationship between them. The areas addressed in this chapter were the major theoretical framework in the study.

### Pedagogical Components of Meaningful Learning

Two sets of pedagogical components of meaningful learning (PCML) were addressed in the study: *Constitutive* component and *Consecutive* component. The constitutive component of meaningful learning is *'relevance'* which describes the connection of the of the topic under study or the learning activity to the following elements associated to students': prior knowledge, interest, real life experience, choice, present worth, future goals and cognitive needs. However, the consecutive component of meaningful learning in this study describes the activities that should be addressed by the teacher in order to engage students in meaningful learning. These activities are divided into five elements and are detailed as follows: *knowledge construction, critical thinking, feedback, learning by doing, and learning based on teaching.*

### 1. Relevance

**The Relevance Theory.** The relevance theory purposes that human cognitive system effectively modifies and adapts the perceptions of the individual about the world. Based on this theory, human ability to understand verbal communication is expressed by that the listener receives voice signals from the speaker, concludes the speaker's intention to transmit a message, and through processing of the signals and the context in which they are conveyed to, the recipient interprets the message (Wilson & Sperber, 2002). At any given moment, the brain is exposed to a lot of information more than it can be attentive to. To be effective, the brain must activate its memory resources, process and filter the information. The brain tends to listen primarily to information that is perceived to be more relevant to it than other information. Such information is captured as information to improve the knowledge and understanding of the individual about the world as efficiently as possible and in the smallest processing efforts (Wilson & Sperber, 2002).

The type of information that can contribute to this purpose is information that relates to existing knowledge, information that corrects misconceptions or provides confirmation and enrichment to existing assumptions. By doing so, the perceptions of the individual receive support or confirmation. The degree of relevance is affected by the context in which the communication exists as well as the level of trust of the listener in the speaker (Wilson & Sperber, 2002).

In contrast, the mind rejects information that does not reinforce existing perceptions in the individual mind, as well as information that contradicts existing assumptions. In a case of new information that is not connected in any way to any existing information, the cognitive system is unable to assess whether it can contribute to the goal or not. New information perceived as relevant may yield the following two results: 1. Make students adjust old assumptions or even abandon them. 2. Support and reinforce old assumptions (Wilson & Sperber, 2002).

Sara Bernard (2010) reports that neurologists believe that personal relevance is essential to the learner brain. Information that is not intrinsically related to what concerns the student is blocked by emotional filters of the brain, and information that is not connected to a prior knowledge does not reach storage in long-term memory, because the information has no scaffolding to hold (Sara, 2010).

**The Relevance Concept.** The term "relevance" typically refers to learning experiences that are directly applicable either to the personal aspirations, interests, or cultural experiences of students and experiences that are connected in some way to real-world issues, problems, and contexts outside of school. Educators argue that relevance, when effectively incorporated into instruction, can increase a student’s motivation to learn, engagement in what is being taught, and even knowledge retention and recall (Glossary of Education Reform, 2013). A literature reviewed by Stuckey et al. (2013) revealed different basic understandings of the term 'Relevance'. For instance, relevance is embedded by connecting science learning to students' interest, students’ lives, students' needs, industry, technology or real-life of individuals and society (Stuckey et al., 2013).

**Relevance as Perquisite for Motivation.** There are several studies that examined the impact of "relevance" on motivation and engagement in learning. From an analysis of interviews of sixty-two award-winning teachers conducted by Kember and McNaught (2007) in Australia and Hong-Kong, ten characteristics of effective teaching have been emerged from the interviews. One of these characteristics was devoted to the importance of presenting "relevance" of the subject to the learner (Kember & McNaught, 2007). Another qualitative study conducted by Hodgson (1984) showed that teachers can motivate their students through utilizing their own interest and enthusiasm and by drawing upon their own experiences. The results of the study provide an incentive to pursue further the subject of motivation through establishing relevance (Hodgson, 1984). Kember et al. (2008) maintains that when a student is exposed to a theory, without a relevant context, the subject being studied is accepted without motivation. On the other hand, when the teacher creates relevant connections which are appropriate for the learner, the motivation of the learner is likely to increase (Kember, Ho & Hong, 2008). Perkins (1992) in his book "Smart schools" suggests that the "relevance" of content to the learner increases the learner's chances of becoming more involved in learning, because "relevance" creates an intrinsic motivation for understanding the content. This intrinsic motivation is important to promote meaningful learning (Mayer, 2002b), thus "relevance" is considered prerequisite to meaningful learning (Yager, 1996; Ausubel, 1978).

Keller (1983) presents a teaching model, which includes four steps to improve motivation in the learning process. One explicitly refers to "relevance". Keller offers several ways to establish "relevance": 1. An explicit statement that the construction of the new knowledge depends on the previous knowledge and experiences. 2. Presenting the importance of the material learned to the student's daily life. 3. Presenting the importance of the subject under study for the student's future and current goals. 4. Giving the students the choice to choose methods or learning styles that meet their needs (Keller, 1983).

According to Keller (1987), relevance can come from the way something is taught; it does not have to come from the content itself. To the extent that an instruction offers opportunities for an individual to satisfy their needs, the person will have a feeling with perceived relevance. On the other hand, Frymier and Shulman (1995) maintain that the more relevant students perceive the content of a class to be, the more likely they are to be engaged by it (Frymier & Shulman,1995).

Another approach for enhancing relevance is suggested by Eccles et al.'s (1983) who proposes the expectancy-value theory for promoting motivation. According to this theory, expectancies (one's beliefs about one's ability to perform on a given task or activity) and values (the underlying reasons for engaging in that task or activity) motivate one's choices and actions with regard to learning activity. With a primary focus on the values component of this theory, there are three primary ways in which the content of a class may be relevant to students: the first type of relevance of class material is related to one's current interests (which aligns with Eccles et al.'s interest value, which is also sometimes called intrinsic value). The second type is that the subject area is perceived as important to one's future goals (which aligns with Eccles et al.'s utility value). The third type is that the subject area is perceived as relevant to one's identity (which aligns with Eccles et al.'s attainment value). There is rich research literature showing that in the absence of valuing the class material, student engagement is diminished (Legault, Green-Demers, & Pelletier, 2006).

**The Relevance Elements.** "Relevance" as mentioned above, describes the connection of the of the topic under study or the learning activity to the following elements associated to students': prior knowledge, interest, real life experience, choice, present worth, future goals and cognitive ability. These elements will be described as below.

*Prior Knowledge*. There is a common belief that students do not arrive to the classroom as empty vessels into which new ideas can be poured by teachers (Tytler, 2002). Students can have prior knowledge that may come from the individual's personal experience in the physical world, through interactions with parents, siblings and friends, from the media and from previous schooling. Some of this prior knowledge is correct; some of it is correct but incomplete; some is only partially correct; and some of it is simply wrong (Michael & Modell, 2003). According to Shulman (2014), "... any new learning must be connected to a certain extent to what the learners already know" (Shulman, 2014). This statement shows the importance of prior knowledge in learning a new topic. Determining students' prior knowledge has been recognized as an important factor in science teaching and an essential for developing teaching strategies

(Novak & Gowin, 1984). Philosopher David Ausubel writes in his meaningful learning theory (Ausubel, 1968): "The most important single factor influencing learning is what the learner already knows, ascertain this and teach him accordingly". This statement grounds all of Ausubel's work on education. According to Hattie (2009), teachers need to be aware of what each and every student thinks and knows, to construct meaning and meaningful experiences (Hattie, 2009). Social and cognitive psychologists, anthropologists and other social scientists have increasingly recognized that the knowledge and experiences children bring to school shape their learning experiences (Bruner, 1996). Learning that builds upon what students already know leads to an increase in not only retention, but in interest and motivation as well (Forbes, Duke, & Prosser, 2001). According to Hattie (2012), what students bring with them to the classroom every year affect his learning achievement. Thus teachers must know what the student already knows and can do. This knowledge enables the teacher to tailor the lesson in a way that gives the student the ability to bridge the gap between his present knowledge and understanding and the knowledge and understanding that have been set as a goal (Hattie, 2012).

Cognitive psychologists present two ways of people respond when they confronted with new knowledge: assimilation and accommodation. Assimilation happens when new information is largely consistent with an individual's prior ideas and beliefs, combines easily with existing knowledge, and reinforces existing views. However, if new information conflicts with existing ideas, the learner may be required to transform previous beliefs. This process is called accommodation. Accommodation is hard work that is essential for conceptual change and, therefore, for new learning (Olsen & Bruner, 1996).

Meaningful learning occurs as students consciously and explicitly connect their new knowledge to existing knowledge structure (Mintzes, Wandersee, & Novak, 1998). In terms of individual constructivism, students are supposed to build their new knowledge based on their prior knowledge. In this perspective on learning, in order to predict how learners will respond to attempts to teach science, it is necessary to understand their pre-instructional knowledge which students bring to a given teaching situation (Leach & Scott, 2003). Students' performance can be improved when instruction is designed to deal with specific difficulties revealed in studies of students' pre-instructional knowledge (Savinainen & Scott 2002).

*Real Life Experience- Authenticity*. A growing body of research suggests that students learn more meaningfully and perform better on complex tasks if they have the opportunity to engage in more “authentic” learning activities that require them to employ subject knowledge to solve real world problems. Herold (2002) describes authentic learning as follows: "In this type of learning, materials and activities are framed around “real life” contexts in which they would be used" (Herold, 2002). Authentic learning relates to real world issues, complex problems, using roleplaying exercises, problem-based activities, case studies and participation in virtual communities (Herrington & Oliver, 2000). An authentic learning experience is one that allows the students to have a voice in what is they are learning, which will ultimately promote a greater student acquisition of the content (Coscarelli, 2012). The Partnership for 21st Century Skills points out that "when students realize the connection between what they are learning and real-world issues that matter to them, their motivation increases, and so does their learning". Research suggests that "When teachers create meaningful learning activities that focus on the resources, strategies and contexts that students will encounter in adult life, absenteeism rates fall, cooperation and communication grow, critical thinking skills and academic performance improve" (Century Curriculum and Instruction, 2007). Constructivists agree on the assumption that learning situations preferably have to resemble real-life or authentic situations. A way to accomplish this is by confronting students with complex, ill-structured problems; similar to the kinds of problems they will face in their future profession. These problems serve as a challenge to students’ reasoning or problem solving skills and as an organizer for their learning (White & Frederiksen, 1998). A study conducted by Perkins et al. (2006) shows that interest in physics declined during a semester-long introductory calculus-based mechanics course. Whereas 19% of the students reported increased interest in physics, 45% reported that their interest in physics decreased. When interest increased, the leading reason was that students reported to see a connection between physics and the real world (Perkins et al., 2006).

*Interest.* Dewey argues that for the purpose of meaningful learning, interest is essential for discovering a real effort to learn. Studies show great importance of interest, as a motivational and learning enhancer (Hidi, 1990). Students are more likely to pay attention and be excited about the learning content when they view the class as relevant to themselves and connected to their interests (Steven, 2014). Interest is conceptualized as a specific relationship between a person and a topic, object, or activity characterized by positive emotional experiences and feelings of personal relevance (value commitment). Various studies show that students with higher interest in a content use deeper-level-processing strategies, or show more persistence and engagement (Alexander & Murphy, 1998).

*Future Goals- Utility Value.* Utility Value suggests alignment between the investment one makes in the class and the expected future payoff of that investment. Utility Value refers to one's ability to connect one's current efforts to future goals (Kauffman & Husman, 2004). Utility Value suggests that even when particular content is not intrinsically interesting to a student, it can be engaged to the extent which is perceived as otherwise important (Jang, 2008). Utility value provides relevance first by inspiring students telling them the content is important to their future goals; it then continues by showing or explaining how the content fits into their plans for the future. This helps students realize the content is not just interesting but also worth knowing (Briggs, 2014).

*Choice.* At the center of the constructivist approach is the student, who must be enabled to have a pace of learning and development, adapted to himself, to set educational, social and personal goals that fit his or her abilities, tendencies and learning methods (Neil, 1977). A learning system based on the application of constructivist theory requires: the freedom of the student to choose the subject in which he is interested, as well as freedom and creativity in organizing the material and in selecting strategies and learning processes (Krumholz, 2000). Malone and Lepper's (1987) study demonstrates the importance of offering student's choices in their activities and learning to encourage them to experience autonomy. Offering for such choice in the classroom has been found to be related to higher intrinsic motivation, engagement, sense of competence, and academic achievement (Patall et al., 2010). Choice can be integrated with some instructional approaches such as inquiry-based approaches to enhance the relevance of classroom material. Thomas (2000) suggests that effective project-based learning approaches involve students choosing their projects and taking responsibility for designing and managing their work (Thomas, 2000). While allowing more choice in the classroom may entail more work for teachers, that can be counterbalanced by implementing cooperative teaching strategies that allow for parallel instruction and homework sharing (Patall et al., 2010).

*Present Worth.* Schools should invite students to engage in learning that is considered valuable to them. Teachers should help students to see the value of investing in the targeted practice of learning school subjects (Purkey, 1992). Students work hard when they value what they learn, that is, when the topic they learn is worth to know or important to them (Mayer, 2002b). All too often, students have very little understanding of the purpose of classroom activities or of the assessment tasks. If they are going to take responsibility for their learning, they need to know what is the big idea or the purposes from learning the subject and how parts of this idea are related and adapted to each other (Earl, 2013).

*Cognitive ability.* The cognitive ability is the ability of the human brain to understand complex ideas, to adapt effectively to learn from experience, and to learn from environment (Broadway and Engle 2011). Learners have different backgrounds, motivation, and preferences in their learning processes. When learning systems ignore these differences they have difficulty in meeting learners' needs effectively (Atman et al. 2009). Therefore, when designing instructional material, it is important to adapt these materials to the individual differences in learning. Learning systems that provide adaptive learning and intelligent support based on learners' characteristics have high potential to make teaching easier, and more effective for both learners and teachers (Macfadyen and Dawson 2010). Clay and Orwig (1999) defined learning style as a unique collection of individual skills and preferences that affects how a person perceives, gathers, and processes information. Teachers should be aware of how well their teaching fit with diverse learning styles can help them in improving their teaching outcomes and providing personalized support for students with different learning styles

## 2. Knowledge Construction

*Knowledge construction* means that**,** knowledge cannot be *transmitted* from one individual to another individual in any mode. Knowledge is actively *built* by the learner using high level internal cognitive process acting on stimuli from the environment (Michael & & Modell, 2003). The internal cognitive process that takes place in knowledge construction takes the forms of students' behaviors of: seeking, interpreting, analyzing, summarizing information, critiquing and reasoning through various options: arguments, justifications and making decisions (Zhu, 2006).

In knowledge construction, learners activate prior knowledge and try to connect new information to knowledge they already possess. The result of knowledge construction involves building mental models or representations of "real world" that can be used to solve problems. The ability to generate multiple representations or models of knowledge being learned and to connect them to prior knowledge is both a sign of deep understanding and important component of meaningful learning as it enables students solving problems in a different situation using this knowledge (Michael & Modell, 2003).

Constructing knowledge is important for students' learning because it ensures students are experiencing meaningful learning (Forbes, Duke, & Prosser, 2001). Ausubel et al. (1978) uses the term 'meaningful' to describe the interaction between new knowledge and previously existing knowledge. This interaction constitutes the 'knowledge construction process' that is one of the fundamental principles of constructivism (Ausubel et al., 1978). People learn best when they make connections or links between what they already know and what they are learning, when they can draw on their experience and make greater meaning of them, when they see how ideas relate to one another, and when they can use what they are learning in concrete ways (Darling-Hammond, 1992). The richer the links, the better the new knowledge will be retained, and the more readily the knowledge can be retrieved for use in problem solving (Michael & Modell, 2003).

The focus of the knowledge construction view is that learning is a change in knowledge due to experience. This view seems most sensitive to the issue of how to promote meaningful learning because it focuses on learning as a search for understanding. When students understand what they learn, they are better able to transfer their learning to new situation (Mayer, 2002b). Studies have shown a positive impact on learning when students participate in lessons that require them to construct and organize knowledge, engage in detailed research, inquiry, writing, and analysis, and to communicate effectively to audiences (Newmann, 1996). For example, a study of more than 2,100 students in 23 schools found significantly higher achievement on intellectually challenging performance tasks for students who experienced knowledge construction (Newmann et al., 1995). In addition, learning that builds upon what students already know leads to an increase in not only retention, but in interest and motivation as well (Forbes et al., 2001).

## 3. Critical Thinking

Thinking is an essential component for meaningful learning occurrence. Teaching that develops thinking contributes to the construction of students' knowledge and helps them to move from learning that emphasizes memorization to learning that emphasizes the construction of knowledge in meaningful ways. Knowledge which is learned in an active way and which develops thinking turns passive and unconnected knowledge into active and connected knowledge, which is the basis for meaningful learning (Perkins, 1998). Knowledge learned in this manner will be better preserved over time and will be applied in many contexts, even beyond the context in which it is taught.

Some studies emphasize that a learning environment, which is designed according to constructivist principles, has positive effects on critical thinking (Maypole & Davies, 2001). Educators have long been aware of the importance of *critical thinking* skills as an outcome of student learning. More recently, the Partnership for 21st Century Skills has identified critical thinking as one of several learning and innovation skills necessary to prepare students for post-secondary education and the workforce (Century Curriculum and Instruction, 2007). *Critical thinking* is not easy to define, because it can be approached from various directions (Lai, 2011).

According to Resnick (1987), high-order thinking skills (analysis, synthesis, and evaluation) should be integrated into all subjects of the curriculum (Resnick, 1987). Critical thinking appears as an essential part of higher order thinking which deals with specific abilities that include: presenting and judging or evaluating arguments, claims, evidence; making inferences (Ennis, 1985; Facione, 1990). Furthermore, it includes other abilities such as: asking and answering questions for clarification; identifying assumptions and making decisions about "what to believe" and "what to do" or solving problems (Ennis, 1985); taking into consideration of other people's points of view to explore alternatives (Ennis, 1985); searching for knowledge from reliable sources for justification (Ennis, 1985); interpreting and explaining (Facione, 1990); reasoning verbally especially in relation to concepts of likelihood and uncertainty (Halpern, 1998); seeing both sides of an issue, being open to new evidence that disconfirms individual's ideas (Willingham, 2007).

Argumentation and evaluation, that are components of critical thinking, are crucial for the construction of reliable knowledge (Ford, 2008). Arguing that opportunities to engage in critique, argumentation and questioning not only help build students' understanding of science but also develop their ability to reason scientifically. Another aspect of critical thinking is the skepticism (McPeck, 1981). People who are critical thinker are skeptical of universal truths, or suspicious of those who declare to have a solution for every problem (Brookfield, 1987). In this manner, there is a delay in judging arguments, conclusions, or solutions to problems until they are properly investigated and ways founded to justify or judge them (McPeck, 1990).

## 4. Feedback

To evaluate deeper understanding, it is essential to assess continuously the extent to which learners' knowledge is integrated, coherent and contextualized (OECD, 2008*b*). Assessments that enable a teacher to evaluate learning while it is occurring is known as formative assessment. Formative assessment enables diagnosis of learning gaps, so they can be addressed before they lead to more fundamental misunderstandings of knowledge or misapplication of skills (Scott, 2015).

Formative assessment promotes meaningful learning by involving students in self-assessment; making learning goals clear to students and monitoring their progress toward these goals; providing feedback to the students and respond to their learning progress (Pellegrino & Hilton, 2012).

*Feedback* as a primary component in formative assessment has been shown to have powerful positive benefits for student learning and achievement (Nichol & McFarlane-Dick, 2009). A meta-analysis carried out by Black and Wiliam (1998) reveals that feedback produces significant benefits in learning and achievement across all content areas, knowledge and skill types and levels of education. Hattie (1987) and Crooks (1988) provide convincing evidence of the value of feedback in promoting learning. Hattie's (2009) synthesis of meta-analyses related to learning found that feedback was one of the most powerful influences on achievement and learning (Hattie, 2009). The effectiveness of formative assessment is strongly related to the quality of the feedback given to students (Crooks, 1988) and action taken by students based on the feedback (Sadler, 1989).

Hattie with colleague Helen Timperley (2007), describe feedback as an information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding (Hattie & Timperley, 2007). Feedback helps learners become aware of any gaps that exist between their desired goal and their current knowledge, understanding, or skill and guides them through actions necessary to improve their learning and obtain this goal (Sadler, 1989). This mean that feedback serves several purposes in narrowing the gap between current state and the desired state. For example, feedback can provide signals that capture attention and help focus success on the task; it can draw attention to the processes needed to complete the task; it can provide information on ideas that were misinterpreted; and can stimulate motivation and encourage students to invest more effort or skill in the task (Hattie & Timperley, 2006).

Sadler (1989) identifies three conditions necessary for students to benefit from feedback in academic tasks. He argued that the student must know: what good performance is (i.e. must possess a concept of the goal or standard being aimed for); how current performance relates to good performance (for this, students must be able to compare current and good performance) and how to act to close the gap between current and good performance.

In formative assessment, teachers use 'assessment for learning' to provide feedback to students about their conceptions and misconceptions; students use their feedback from teachers to adjust their understandings, rethink and reflect on their ideas, and put their new conceptions forward. It also provides teachers information that will allow them to modify the teaching and learning activities and plan for better instruction. To do this, teachers use observations, worksheets, questioning in class or any other mechanism (Earl, 2013). Research shows that 'assessment for learning' is one of the most important ways to promote meaningful learning and to raise learner achievement (Assessment Reform Group, 2002). Optimal 'assessment for learning' process promotes thinking and problem-solving skills (Black & Wiliam, 2006) and raises the motivation for deeper learning (Harlen, 2006).

While feedback generally originates from a teachers' assessment, learners can also play an important role through 'self-assessment'. Students use their feedback from self-assessment to evaluate their own work according to predefined criteria, often using tools, such as a rubric or focus questions (Barron & Hammond, 2008). This will help them to monitor their understandings, rethink and reflect on their ideas, and make adjustments, adaptions, and even major changes in what they understand. This is the regulatory process in metacognition. Students learn to take control and responsibility of their learning by defining learning goals and monitoring their progress in achieving them (Earl, 2013). Studies have shown that the self-feedback that the learner himself produces is more effective than feedback from an external source (e.g. teacher) (Black & Wiliam, 1998). In addition, it was found that self-feedback promotes internal motivation and a sense of efficacy (Harlen, 2006).

Teachers should focus much more effort on strengthening the skills of self-assessment in their students (Yorke, 2003). This will help them master content and improve their metacognitive skills, including the ability to learn how to learn and to reflect on what they have learned (Saavedra & Opfer, 2012). Two experimental research studies have shown that students who understand the learning objectives and assessment criteria and have opportunities to reflect on their work show greater improvement than those who do not (Fontana & Fernandes, 1994; Frederikson & White, 1997).

McGarrell and Verbeem (2007) provide a summary of effective feedback characteristics to consider when providing feedback on written work and drafts such as: asking probing questions about key areas of their assignment; encouraging students to think more deeply about their work; giving personal feedback that is more likely to motivate meaningful revision; avoiding using statements such as “good” or “interesting” because these statements will be confusing for students and they will not understand why that part of the assignment was good but another part was not, using these statements requires explanation (McGarrell & Verbeem, 2007).

Feedback is an integral part of learning and teaching. Thus, providing detailed and ongoing feedback is necessary for effective learning as students need information about their accomplishments in order to grow and progress (Hipkins et al., 2002). Studies show that the most helpful type of feedback on tests and homework provides specific comments about errors and specific suggestions for improvement and encourages students to focus their attention thoughtfully on the task rather than on simply getting the right answer (Bangert-Drowns, Kulick, & Morgan, 1991).

To promote meaningful learning, feedback is useful when it presented as information intended to guide the learner's construction of knowledge and instill intrinsic motivation. Meaningful learning is not promoted when feedback is presented as reinforcement intended to automatically increase or decrease a response. In this view, learning depends not on the feedback but rather on the learner's interpretation of the meaning of the feedback (Mayer, 2002b).

## 5. Learning by Doing

Learning by doing means learning from experiences resulting directly from one's own actions, watching others perform, reading others' instructions or descriptions or listening to others' lectures (Hayne, 2011). Learning by doing is based on three assumptions (Smith, 1980):

1. People learn best when they are personally involved in the learning experience;
2. Knowledge has to be discovered by the individual if it is to have any significant meaning to them or make a difference in their behavior; and
3. A person's commitment to learning is highest when they are free to set their own learning objectives and are able to actively pursue them within a given framework.

People have known for hundreds of years that they remember what they see and do. A 2000-year-old proverb attributed to Confucius states: "I hear and I forget, I see and I remember, I do and I understand". This quote express how experiential learning is effective. In this regard, Stice (1987) indicates that learners remember only ten percent of what they read, 26 percent of what they hear, 30 percent of what they see, 50 percent of what they see and hear, 70 percent of what they say, and 90 percent of what they say as they do something.

Both John Dewey and Jean Piaget theories assert the importance of engagement in meaningful learning activities. Dewey (1900) believes that students construct knowledge through experiences that are meaningful to them. He also believes that these experiences must occur in social situations in which students work together. Dewey (1922) felt strongly that most students learned a type of science that was not connected in meaningful ways to their world. Based on Dewey point of view, science in the schools should connects the child to the real world of work and others. As a result, science not only serves to teach students practical skills, but group and social skills as well. This differed significantly from the standard practice of the day, which according to Dewey, isolated "science from significant experience" (Dewey, 1922).

Piaget (1972) states that the physical activity of the learner in his environment is the basis to his learning. He calls on the cancellation of the formal verbal teaching, he also believes that: passive absorption of facts and formulas have little values; the condition to simplified thinking is an earlier experience with contact with objects; the child is active in his essence; the natural motivation to learning is intrinsic, contrary to behaviorists view which claims that the motivation to learning has to come from outside in the shape of prizes or punishments (Piaget, 1972). Enlarging experience is as much about the deepening of an understanding of our experiences as it is about building them up, arguing that we 'work with people so that they may have a greater understanding or appreciation of their experiences' (Jeffs & Smith, 2005).

According to Mayer (2001), the best way to promote meaningful learning outcomes lies in active learning, meaningful learning outcomes occur as a result of the learners' activity during learning. In active learning, as defined by Bonwell and Eison (1991), students are doing things and thinking about what they are doing. In this view of learning, it is the learners who are responsible for their understanding and their own active construction of meaning and the teacher role is to facilitate that (Bonwell & Eison, 1991).

Mayer (2001) points out that there are two types of learning activity: cognitive activity and behavioral (physical) activity. Behavioral or physical activity refers to what's going on with the learners' physical behavior such as the degree of hands-on activity. Physical activity (students are doing things) that invites a direct and tangible encounter of the learners with the components through experiments observations such as: operating on instruments, analysis and construction of products (Israel. Ministry of Education, 2018). Cognitive activity refers to what's going on the learner mind such as the degree of integrative cognitive processing (thinking about what they are doing). It invites students to use high-order thinking skills, involves questioning and independent involvement in the learning process, information processing, conceptualization, generalization and evaluation (Israel. Ministry of Education, 2018).

Physical activity has been found to have a positive effect on children’s cognitive functions such as: memory, attention, general information processing and problem-solving skills. The latest studies indicated that increasing physical activity improves test results, particularly in tasks requiring executive functions and memory (Kangasvieri et al., 2011).

Greenberg (2014) notes in his article "Active Children, Smart Children" the importance of physical activity to normal brain development and improved management skills including the ability to solve complex problems, process information and activate memory, concentration and attention (Greenberg, 2014). In addition, physical activity increases brain volume and its activity particularly in regions associated with memory and executive functions. At its best, engaging in physical activities develops teamwork skills, self-direction and the ability to co-operate with different people (Kangasvieri et al., 2011).

Research on learning shows that meaningful learning depends on the learners' cognitive activity during learning rather than on learners' behavioral activity during learning. It might suppose that the best way to promote meaningful learning is through hands-on activity. However, behavioral activity per se does not guarantee cognitively active learning; it is possible to engage hands-on activities that do not promote active cognitive processing. In this case the activity does not foster meaningful outcomes. Mayer (2001) assumption is that well designed instruction lesson can promote active cognitive processing in learners even when learners seem to be behaviorally inactive. If meaningful learning depends on active cognitive processing in the learner, then it is important to design learning experiences that promote appropriate cognitive processing (Mayer, 2001). This finding supported by Pines (1985) who points out that meaningful learning does not occur by learning more facts and principles or increasing the number of students' physical activities. The emphasis is that "hand on" will not, by itself, improve students' understanding of science. What is additionally needed is a "minds on" emphasis in the learning of science (Pines, 1985).

Indeed, “learning by doing” has a somewhat checkered track record, in part because teachers often lack the information, support, and tools necessary to fully integrate and support this alternative approach to teaching and learning (Barron & Hammond, 2008).

## 6. Learning Based on Teaching (concepts and skills)

One way in which the richness of the learning context can be increased is to encourage the learner to generate his or her "self-explanation" for the new knowledge or skills being acquired. This "self-explanation" effect has been studied extensively, and the benefits have been clearly established (Chi, DeLeeuw, Chiu & LaVancher, 1994). Acting as a teacher ("the best way to learn something is to teach it") is another way to facilitate learning, since teaching requires to generate of explanations, both for oneself and for the learner. Students who become teachers of others, learn no less than the students they teach. The contention here is that students learn more when they are teachers of themselves and others (Michael & Modell, 2003).

According to Hattie (2012), students learn a lot when they asked to teach something, not just to sit and listen to others. This strategy promotes the constructivist component of self-regulation and mastery of their learning (Hattie, 2012). Learning based on teaching also known as peer tutoring or peer instruction. It is a teaching and learning approach which was developed by the French language teacher Jean-Pol Martin in German schools in the 1980s (Martin, 1985). The basic idea of 'learning based on teaching' is that learners take the role of the teacher for a certain time in class. This time period can be a whole lesson or only the time needed for a special activity. During this time period, the learners enhance their learning experience by encouraging them to teach other students and collaborate with peers (Hatano and Inagaki, 1991). This can be done by forming a group consist of 2-5 students. Each group may present new concepts to research on, discuss among members and decide on the strategies to use for teaching the concepts to the rest of the class (Martin,2008; Skinner,2006). In this approach, students are able to construct knowledge together and come to a shared meaning of these concepts in ways that are more conducive and permissive. On one hand, allowing students to assume the teaching role allow learners' prior knowledge to promote meaningful and effective learning (Deer and Wolfe, 2001), in turn this can be a source of motivation to learn (Shor and Freire, 1987).

Grzega and Schöner (2008) emphasize that by using learning based on teaching methods, "learners are given the chance to acquire creativity, independence, self-confidence and key competencies, such as the ability to work in teams, the ability to communicate, complex thinking, the competence to seek and find information, explorative behavior, presentation skills, project competence, internet skills, the ability to structure information and generate knowledge, punctuality, reliability and patience" (Grzega & Schöner, 2008).

Peer instruction is a teaching method which was developed by Mazur (2009). It has been used in numerous science and mathematics courses. Peer Instruction is an active-learning teaching method that can be employed to increase student learning. Peer instruction attempts to involve students to explain to each other how they understand core physics concepts. The emphasis is not on getting to a right answer via a mechanical process; instead, the right answer is apparent once the students use the appropriate core concepts in their attempts to articulate their understanding of the problem and their solution to it. In a variety of studies, this approach has been shown to improve learning twofold over the standard lecture format (Crouch, 2001; Hake, 1998).

Study conducted by Cortright, Collins and DiCarlo (2005) to examine the effectiveness of peer instruction on meaningful learning. The study carried out on undergraduate exercise physiology class of 38 students was randomly divided into two equal groups, a randomized crossover design in which students either answered questions individually or during peer instruction was used to control for time and order effects. The first factor that influences meaningful learning is the degree of mastery of the original material. Finding from this study was that peer instruction significantly enhanced mastery of the original material. Furthermore, the student's ability to solve novel problems was significantly enhanced following peer instruction. This finding supported the hypothesis of this study that peer instruction enhanced meaningful learning (Cortright et al., 2005).

Peer tutoring defined by Topping (1998) as "People from similar social groupings who are not professional teachers helping each other to learn and learning themselves by teaching." Topping, Duran and Van (2015) also explain the benefits of peer tutoring as helping the students improve not only academically, but also reducing the psychological stress of learning on the students (Topping et al., 2015). Chan (2003) demonstrates in his study that letting students take control over their own learning allows them to feel more responsible for their learning. This pushes them to find learning styles and resources that best suit them (Chan, 2003).

### Teachers' Beliefs and Practice and their Relationship

Teachers’ beliefs and practice are important for understanding and improving educational processes. They are closely linked to teachers’ strategies for coping with challenges in their daily professional life and to their general well-being. In addition, they shape students’ learning environment and influence student motivation and achievement (OECD, 2009).

Since beliefs are thought to be action agendas (Pajares, 1992) and teachers are expected to play a crucial role in changing schools and classrooms (Prawat ,1992), identifying and understanding the beliefs of teachers regarding any educational reform idea becomes critical (Bybee, 1993). Because of different beliefs of teachers, various kinds of teaching practices would be implemented in classrooms (Shapiro, 1994).

Beliefs have been widely discussed in the literature. Beliefs used interchangeably with a variety of other terms such as: attitudes, values, judgments, opinions, perceptions, conceptions, conceptual systems, ideology, dispositions, implicit theories, internal mental processes, action strategies, rules of practice and perspectives (Pajares, 1992). Several studies provide a variety of definitions of beliefs. According to Pajares (1992), “Beliefs influence how individuals characterize phenomena and make sense of the world” (Pajares, 1992). Rokeach (1972) defines beliefs as “any simple proposition, conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase ‘I believe that'. Rokeach discussed three kinds of beliefs: descriptive beliefs, evaluative beliefs and prescriptive beliefs. In descriptive beliefs, the object of belief is described as true or false, correct or incorrect. In evaluative beliefs, beliefs can be stated as good or bad. In prescriptive beliefs, a certain action or a situation is advocated as desirable or undesirable (Rokeach, 1972). Loucks-Horsley et al. (1998) argued that, “beliefs are more than opinions: they may be less than ideal truth, but we are committed to them” (Loucks-Horsley et al., 1998). Haney et al. (2003) defined beliefs as “one’s convictions, philosophy, tenets, or opinions about teaching and learning” (Haney et al., 2003).

Teachers' instructional practices are influenced by many factors and one of those is teachers' beliefs. The literature has demonstrated the significant influence of teachers' beliefs on the implementation of school reforms (Yan 2014). The literature review has been widely discussed the relationship between teacher beliefs and classroom practice. A number of studies investigating the relationship between teacher beliefs and practice have found that teacher beliefs are consistent with classroom practice (Ernest, 1988; Pajares, 1992; Bandura, 1986; Clark and Peterson, 1986).

Pajares (1992) asserts that beliefs are "the best indicators of the decisions individuals make throughout their lives". He suggests "a strong relationship between teachers' educational beliefs and their planning, instructional decisions, and classroom practices" (Pajares, 1992). According to Bandura (1986), an individual's decisions throughout his/her life is strongly influenced by his/her beliefs (Bandura, 1986). Ernest (1988) argued that teachers' beliefs have a powerful impact on the practice of teaching (Ernest, 1988) and Clark and Peterson (1986) described teachers' beliefs and theories as "the rich store of knowledge that teachers have that affects their planning and their interactive thoughts and decisions" (Ernest, 1988; Clark and Peterson, 1986). However, other research reports about the relationship between teacher beliefs and practice show that teacher beliefs are inconsistent with classroom practice. This means that teachers' beliefs do not necessarily have a direct causal bearing on their actions (Tobin, Tippins, & Gallard, 1994).

The relationship between teacher beliefs and practice is also documented in science education literature. A research evidence has shown that teachers' beliefs about teaching and the learning of science influence their teaching practices (Fang, 1996; Laplante, 1997). In this regard a wide range of issues in science education was discussed including: (a) constructivism (Haney & McArthur, 2002); (b) goals of science education (Mcintosh & Zeidler, 1988); (c) inquiry (Wallace & Kang, 2004); (d) nature of science (Lederman, 1999); (e) science, technology and society, (Lumpe, Haney, & Czerniak, 1998); (f) curriculum (Cronin-Jones, 1991) and (g) teaching and learning (Hancock & Gallard, 2004). These studies indicate that the relationship between teacher beliefs and practice is controversial. These studies also indicate that teacher beliefs should be considered within context. Thus, it is necessary to take into account the contextual factors that have shaped and formed certain beliefs (Pajares, 1992).

The term "beliefs" used in this study refer to the perceptions or way of thinking as declared by science teachers towards the main pedagogical components of meaningful learning. However, the term "practice" refer to the actions or behaviors that teachers carry out in the class which align with the pedagogical components of meaningful learning. The relationship between beliefs and practice of pedagogical components of meaningful learning was examined.

# CHAPTER IV

# RESEARCH METHODOLOGY

This chapter presents the subject and the objectives of the research; the research questions, variables and indicators; the research approaches, methods and instruments; the research organization: procedures and preliminary research; the study population and sample and the data analysis.

## 1. Subject and Objectives of the Research

The current study aims to evaluate science teachers' beliefs in Arab middle schools in Northern Israel and their practice of specific pedagogical components which are crucial for promoting meaningful learning (ML). In addition, this study seeks to determine whether teachers' beliefs have any relationship with their practice of these components. The researcher has also explored background factors, such as gender, years of teaching, educational qualification and school type, in order to determine whether they affect teachers' practice of the PCML. In addition, this study attempts to identify obstacles that might impede the implementation of meaningful learning, and conditions suggested by science teachers in middle schools to improve it.

## 2. Research Questions, Variables and Indicators

**Research Questions**. The main research questions for the quantitative approach are:

1. What are the science teachers' beliefs and practice of specific pedagogical components of meaningful learning in Arab middle schools in northern Israel?
2. What are the correlations between science teachers' beliefs and their practice of pedagogical components of meaningful learning?
3. What are the correlations between specific background variables of science teachers and their practice of pedagogical components of meaningful learning?

The main research questions for the qualitative approach are:

4. What conditions should be provided to enhance meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion?

5. What obstacles do science teachers face in implementing the meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion?

**Research Variables.** The variables of this study are:

**1. Explanatory (Independent) Variables:**

1. Gender (Male, Female)
2. Educational qualification (B.Sc./B.Ed., M.Sc./M.Ed./ Ph.D.)
3. Years of teaching experience (1-5 Y, 6-10 Y, 11-15 Y, above 15 Y)
4. School Type (State, Private)

**2. Explained (Dependent) Variables and Definitions:**

1. Beliefs- The term "beliefs" in this study refers to the perceptions or way of thinking as offered by science teachers towards the main pedagogical components of the meaningful learning.

2. Practice- the term "practice" in this study refers to the actions or behaviors that teachers carry out in the class which align with the components of meaningful learning.

## 3. Research Approaches, Methods and Instruments

**The Research Approaches.** In this cross-sectional study a qualitative and quantitative research approaches were applied to address the research questions. The study has a descriptive and correlative design. The quantitative approach using questionnaire was applied to answer the first question that aims to assess and describe science teachers' *beliefs* toward pedagogical components of meaningful learning (PCML) and the extent of *practice* these components when teaching science in the Arab middle schools in northern Israel. Based on the data were gathered by the first question, correlational statistics used to address the second and the third questions to describe and measure correlations (relationships) between variables. Accordingly, the second question attempts to explore correlations between teachers' *beliefs* and *practice* of the PCML; the third question attempts to explore correlations between selected teachers' personal and professional background variables and their *practice* the relevant PCML. The quantitative approach was selected to provide quantitative data about the science teachers' *beliefs* and *practice* of six pedagogical components of meaningful learning

(PCML) which were identified qualitatively by an interview conducted in a previous preliminary pilot research (refer Appendix E). These components perceived by science teachers in middle schools as being the components they actually practice in their science teaching and which align with pedagogical components set by the Israeli Ministry of Education (Israel. Ministry of Education, 2018) for enhancing meaningful learning in schools. Consequently, these components form the major quantitative research framework of the study.

The qualitative approach using semi-structured interview with open-ended questions was applied to address the fourth research question that aimed to establish a set of recommendations based on the teachers' suggestions on how they would improve implementation of meaningful learning in science teaching in middle schools. Also it was applied to address the fifth research question that aimed to identify obstacles that affect the implementing the meaningful learning according to teachers' opinions. The interview was the preferred method to address these questions and was chosen after an exploratory pilot study in which the fourth and the fifth research questions were distributed randomly to several teachers as open-ended questions. The teachers' responses were superficial and limited, and it was not possible to derive and gather comprehensive and profound information. Therefore, it was decided to use the interview to obtain more information and to raise points that the researcher was not aware of. The second reason the researcher adopted the interview method is that he is a part of the science teachers' community in middle schools, this may make the interview more relevant for both to the researcher and to the participants due to a common professional interest for improving science teaching in middle schools.

**Research Instruments.** As mentioned above, two research instruments were used in this study to collect data, a questionnaire and an interview, as described below.

**Questionnaire:** A questionnaire was constructed for science teachers in middle schools. The main subjects addressed in the questionnaire are *beliefs* and *practice* related to pedagogical components of meaningful learning (PCML). The items in the questionnaire were developed by the researcher for this study based almost on the literature review and previous studies. The estimated time for filling the questionnaire was about 15-20 minutes. The questionnaire included two parts; every part is described in details as follow:

**Part I**- This part included selected personal and professional background characteristics of teachers such as gender, years of teaching experience, type of school and educational qualification (explanatory variables). This information enables us to identify additional correlations between these variables and the *practice* of pedagogical components of meaningful learning. Because these personal and professional background variables are derived from previous studies, they are considered to have validity and reliability for use in the study.

**Part II**- The main subjects addressed in this part are *beliefs* and *practice* related to six pedagogical components of meaningful learning as follow: relevance, knowledge construction, critical thinking, feedback, learning by doing and learning based on teaching. This part included two sections:
*1. Teachers' beliefs section.* Items included in the *beliefs section* of the questionnaire had been designed to assess the prevailing beliefs toward six pedagogical components of meaningful learning (PCML). Statements were provided, and respondents were asked to indicate the extent to which they agree with those statements on a 4-point Likert scale: strongly disagree (1 point), disagree (2 points), agree (3 points) and strongly agree (4 point). This section included 37 items divided across the six PCML. The *'relevance'* component consists of 7 items (items 1-7). Items for example: "Students learn better when they know how the content can be applied in daily life", "Teacher is supposed to provide challenging tasks that are adapted to the learner's unique abilities, that lead him/her to success and excellence", the '*knowledge construction'* component consists of 5 items (items 8-12). Items for example: "Students learn more effectively if they relate the material they learn to what they previously learned", "Students learn best by finding solutions to problems themselves"; the *'critical thinking*' component consists of 8 items (items 13-20). Items for example: "Students are supposed to provide explanations and reasons why their point of view is the right one", "Students are supposed to bring contradictory evidence to ideas presented by others", the "Feedback" component consists of 7 items (items 21-27). Items for example: "Learning becomes more effective when students assess personally their learning progress", "It is a waste of time to give detailed written feedback on students' work in addition to marking", the *'learning by doing*' consists of 5 items (items 28-32). Items for example: "Learning a topic by doing leads to a better understanding of this topic", "Student who learns by doing will understand the material faster, compared to learning it by listening to a

teacher's lecture"; and the *'learning based on teaching'* consists of 5 items (items 33-37). Items for example: "Student who learns new content by himself/herself in order to teach it to his/her classmates will better understand this content, compared to learning it by listening to a teacher's lecture", "Student who learns new content by himself/herself in order to teach it to his/her classmates, invest more time and efforts, compared to learning by listening to a teacher's lecture" (see Appendix B for total items).

*2. Teachers' practice section.* Items included in this section of the questionnaire had been designed to assess the *practice* of science teachers the selected pedagogical components of meaningful learning (PCML). Statements were provided, and respondents were asked to indicate the frequency to which they practice these components in their teaching science on a pre-determined scale. The four response categories are the following: Never (1 point), Occasionally (2 points), Frequently (3 points) and Always (4 points). This section includes 29 items divided across the six pedagogical components of meaningful learning. The *'relevance'* component consists of 7 items (items 1-7). Items for example: "I give a learning activity or a task based on the students' personal interest", "Students are given various tasks and learning activities adapted to their abilities and pace of learning", the *'knowledge construction'* component consists of 5 items (items 8-12). Item for example: "Students are given the opportunities to make connections between concepts that will be learned in the future and concepts the they already know", the *'critical thinking'* component consists of 8 items (items 13-20). Item for example: "Students are given the opportunity to present arguments and provide reasons to justify them", the *'feedback'* component consists of 7 items (items 21-27). Item for example: "When students perform a task they receive immediate feedback", the *'learning by doing'* consists of 1 item (item 28) for example: "During the last year the students were given the opportunity to learn by doing (e.g. conducting experiments, building models or products, taking measurements, conducting research, using project based learning and so on)", and the *'learning based on teaching'* consists of 1item (item 29) for example: "During the last year the students were given the opportunity to teach or guide other students or the whole class or to present a subject or problem that he or she worked on it" (see Appendix B for total items).

**Content Validity of the Questionnaire.** Content validity of the questionnaire estimated by examining the extent to which the items cover the content they were intended to measure (Creswell, 2014). It based on professional judges' point of view about the relevance of the items to the contents of a particular component of meaningful learning. To verify the content validity of the second part of the questionnaire which deals with the evaluation of the teachers' *beliefs* and *practice* regarding pedagogical components of meaningful learning (PCML), the items presented in its initial form (refer Appendix A) reviewed by a group of ten professional judges. The judges were chosen purposely due their rich experience in teaching science and particularly have the sufficient theoretical and practical background in meaningful learning pedagogy. They asked to express their opinion on the items with relevance to the PCML to be measured, on the accuracy and correctness of the items, on the clarity and on the linguistic formulation of the items and the level of difficulty. The experts allowed to modify or delete irrelevant parts and to give their opinion on the scale. Corrections have been made after giving their comments to achieve the final instrument.

**Reliability of the Questionnaire.** The reliability of the questionnaire in both parts was examined by calculating the internal consistency by using Cronbach's alpha coefficients (Creswell, 2014)**.** This type of reliability indicates the strength of the correlation between the items in the study instrument. Table 1 presents the components in the *beliefs* section of the questionnaire and the Cronbach's alpha values of the items in each component.

**Table 1:** Reliability as internal consistency of components in the *beliefs* section

| **Component** | **Items** | **Cronbach's Alpha** |
|---|---|---|
| Relevance (R) | 1 – 7 | **0.633** |
| Knowledge construction (KC) | 8 – 12 | **0.662** |
| Critical thinking (CT) | 13 – 20 | **0.757** |
| Feedback (FB) | 21 – 27 | **0.610** |
| Learning by doing (LBD) | 28 – 32 | **0.775** |
| Learning based on teaching (LBT) | 33 – 37 | **0.749** |

Each component of the six components (dimensions) appears in Table 1 above was constructed by calculating the mean value of the teachers' beliefs toward the items that construct each component, as each item received a value from 1 to 4. A higher mean value of the beliefs toward a component indicates a more positive attitude towards this component. As it shown in Table 2 the values of Alpha Cronbach ranged from 0.610 to 0.775, thus it can be assumed that the questionnaire is reliable in all its components. Table 2 presents the components in the *practice* section of the questionnaire and Cronbach's alpha values of the items in each component.

**Table 2:** Reliability as internal consistency of components in the *practice* section

| Component | Items | Cronbach's Alpha |
|---|---|---|
| Relevance (R) | 1 – 7 | **0.773** |
| Knowledge construction (KC) | 8 – 12 | **0.794** |
| Critical thinking (CT) | 13 – 20 | **0.900** |
| Feedback (FB) | 21 – 27 | **0.843** |
| Learning by doing (LBD) | 28 | **-** |
| Learning based on teaching (LBT) | 29 | **-** |

Each component of the six components (dimensions) appears in Table 2 above was constructed by calculating the mean value of the teachers' practice as described in the items that construct each component, as each item received a value from 1 to 4. A higher mean value of the practice of the component indicates a more frequent practice of this component. As it shown in Table 3 according to the values of Alpha Cronbach, it can be determined that the questionnaire is reliable in all its components.

**Interview:** Semi- structured interview had been applied to address the fourth and the fifth research questions. The fourth research question aimed to identify the main conditions in three contexts for improving the implementing of meaningful learning in middle schools in science teaching according to science teachers' opinions. Three sub-questions were derived from the fourth research question: The first question was related to conditions at the pedagogical context (in terms of curriculum, educational climate, physical structure and equipment, professional development, resources, teacher role, others), the second question related to conditions at the administrative context (in terms of teaching patterns, teaching-learning activities, assessment methods, learning environments, others), and the third question related to conditions at the student context (role of student, student's characteristics, opportunities to be given to the students). As well, the fifth research question aimed to identify obstacles may hinder the implementing of the meaningful learning in middle schools in science teaching according to science teachers' opinions. The interview included the following questions:

1. In your opinion, what kind of pedagogical conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?
2. In your opinion, what kind of administrative conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?
3. In your opinion, what kind of conditions related to students could improve implementing of meaningful learning in science teaching in Arab middle schools?
4. In your opinion, what obstacles do science teachers face in implementing the meaningful learning in science teaching in Arab middle schools?

The question (1-3) belongs to the fourth research question and the question 4 belongs to the fifth research question.

**Trustworthiness of the Interview Questions.** Trustworthiness in qualitative research is the alternative term of validity and reliability in quantitative research. In qualitative research, there is no separation between quality criteria of the research instruments (validity and reliability) and quality criteria of the research results that have undergone processing, analysis and report. This may be due to the fact that research procedure and data collection, analysis, presentation and interpretation are consistent and interrelated (Zedan, 2018). Trustworthiness of the interview in this study obtained through the preservation of the ethics of research, carrying out a dialogue with the participants and giving a space to the participant to express his perceptions and understanding of events (Lincoln & Guba, 1985). To increase confidence in results, time and efforts were invested in gathering information and documenting information professionally (Josselson & Lieblich, 2003). To obtain a theoretical validity in this interview two strategies were used: peer debriefing, in which one peer and supervisor were involved to review and evaluate the results and examined interpretations. The second strategy was the prolonged engagement in the field which expressed in this study as the researcher is a part of the science teachers' community in middle schools and he have the sufficient knowledge in the researched topic. This may make the interview more relevant both to the researcher and the participants. In addition, thick and rich descriptions from the interviewees responses were quoted for increasing the interpretive validity of the interview (Creswell & Dana, 2000).

**Informed Consent Form of the Instruments.** This part of the instruments, includes the following sections: title of the study, researcher's name, university and faculty, contact details (including email address and/or phone number), purpose of the research, what will the teacher be asked to do, discomforts, benefits of the research and benefits to the researcher, a statement regarding voluntary participation, keeping anonymity, conditions to withdraw from the study, questions arise about the research.

### 4. Research Organization: Preliminary Pilot Research and Procedures

**Preliminary Pilot Research.** This qualitative pilot study aimed to explore individual beliefs, experiences and perceptions of science teachers in middle schools and to identify the presence of elements which are crucial for promoting meaningful learning in science teaching. Semi-structured interviews were conducted with six science teachers who work at a full-time job at different Arab middle schools in the Galilee district in Israel. The research sample was selected based on their rich experience in teaching science.

To achieve the research objectives, two assignments were given individually to every teacher. The first assignment was: 'Describe one science lesson you remember as the best you have taught'. The second assignment was: 'Describe your philosophy about science teaching'. These assignments were aimed at identifying perceptions, beliefs and practices in science teaching which are consistent with meaningful learning. The descriptions obtained from the interviews were collected based on sub-questions focusing on specific points regarding teaching-learning processes in science (refer appendix E). The content emerged from the interview were analyzed qualitatively based on the theoretical constructivist model.

The results show that some of the teachers' beliefs and practices in science teaching are consistent with teaching relate to meaningful learning. Science teachers' descriptions led to the identification of six elements as follow: *authenticity, prior knowledge. learning based on teaching, Knowledge construction, learning by doing,* and *feedback.* The following quotes are examples for each component which presented by the interviewees.

An example shows how *authenticity* is integrated in one science lesson dealt with the issue of the impact of materials on the environment: *"We have discussed the new law which demands that every consumer must pay for the plastic bag, which is used to fill purchases when we do shopping"*. The following example shows how "prior knowledge" comes into expression in other science learning activity: *"Before we began the learning activity we used sun associations, discussions and questions to reveal what students know about the topic"*. An additional example also shows how *knowledge construction* is integrated during lab activity: *"After the students carry out the experiment, they are given the opportunity to ask questions about the experience, they explain the results and draw conclusion"*. *Learning by doing* involves students in a physical as well as mental activity. An example described by one teacher was: *"We talked about the process of water cycle. We prepared and used objects manufactured from simple materials in the shape of the sun, clouds, drops of water, river, sea and valleys"*. The following example relates to using *feedback* in the science lessons: *"In order to assess students' understanding of the lesson, questions were asked before, during and at the end of the lesson to get feedback from them in order to improve learning"*. An example of *learning based on teaching* was: *"Students worked in small heterogeneous groups to learn about materials properties. Every group worked on different property and they have to present what they learn to their classmate"*.

These components and other components such as *critical thinking* and *relevance* (that includes among others the *prior knowledge and authencity* elements) constituted the major framework of this study. (see Appendix E for more details).

**Procedure of the Questionnaire Construction**. The pedagogical components were selected based on the early pilot study and literature review within the supervisor's guidance. The items of each component were created based on literature and previous studies. The researcher first prepared the questionnaire in English and then translated it into Hebrew. To minimize misunderstanding, corrections in both languages were made by professional editors. After the creation of the items, a series of pilots-testing were carried out by experts to examine whether the instruments are correctly understood and changes were made accordingly until the wording, the length and the structure of the instruments are final. Validity and reliability procedures of the instruments had been examined as described above.

**Procedure of the Questionnaire Administration**. The researcher contacted all teachers by phone and concisely explained the importance of the study and its objectives and tried to obtain their collaboration. Following the conversation and their getting permission to participate in the study, the researcher sent a link of the questionnaire by E-mail or WhatsApp reiterating the importance of the research and asking them to fill in the questionnaire. The E-mail or the WhatsApp followed by a telephone call to clarify any doubts. The researcher made follow-up calls to each teacher individually and encourage her/him to fill the questionnaire and return it. The timeline for administering the survey was between 15 and 20 minutes in length. The questionnaires were transferred to the teachers between November 2018 and February 2019.

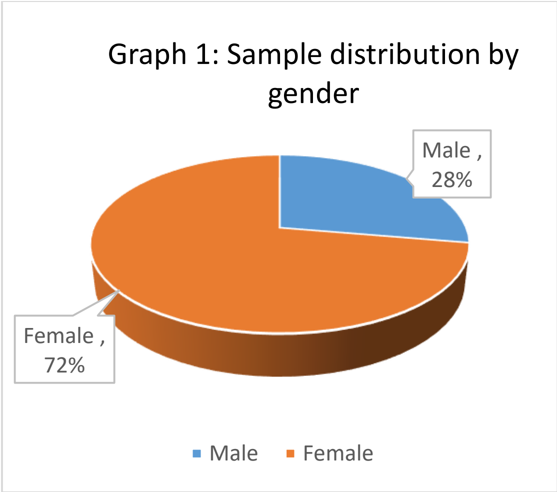
**Procedure of the Interview Conducting**. The researcher contacted by phone all teachers who showed interest in participating in the qualitative part of this research and briefly explained the importance of the study and its objectives and tried to obtain their collaboration. Following the conversation and getting their permission to participate in the study, the researcher organized an appointment for a personal interview individually. The semi-structured interviews with individuals were between thirty and fifty minutes in length.

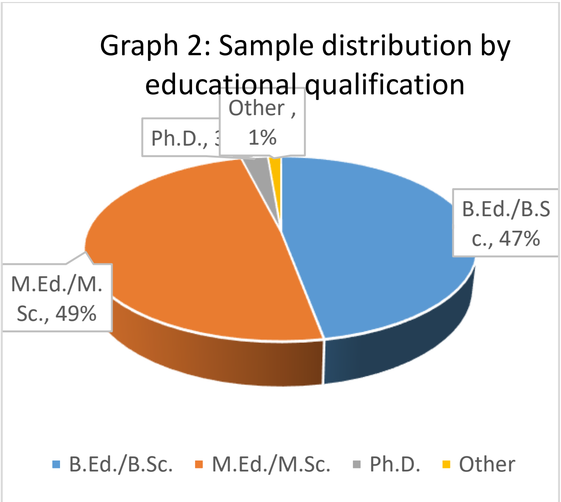
## 5. Study Population and Sample

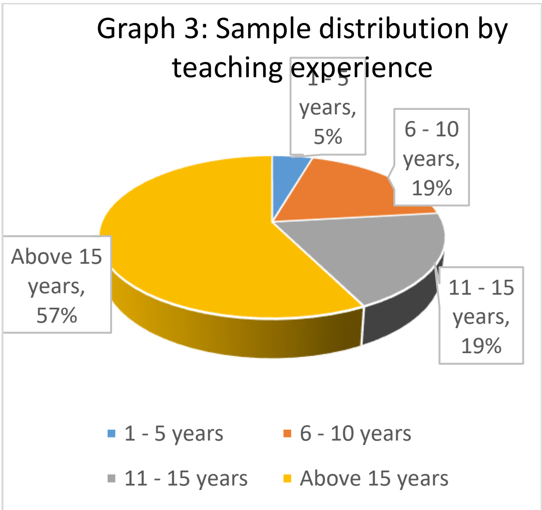
**Questionnaire- Sampling Method.** The study population consists of all science teachers (N=250) employed in about 85 middle schools registered in the Arab educational sector in northern district (galilee and the Haifa district) in Israel. Most of these schools (about 60) are state middle schools and the rest (about 25) are private schools. The middle school level spanning three years of learning ($7^{th}$-$9^{th}$ grades). Most of the state schools are independent middle schools ($7^{th}$-$9^{th}$ grades) and the rest are linked to a level spanning six-year of learning of high school ($7^{th}$-$12^{th}$ grades). Most of the private schools are at level spanning eight years of learning (1-$8^{th}$ grades) the rest are at level spanning four-year of learning of high school ($9^{th}$-$12^{th}$ grades). In this study the population consists only of science teachers of $7^{th}$-$8^{th}$ grades employed in private schools that are at level spanning eight years of learning (1-8th grades). All Arab middle schools' science teachers in northern Israel counted about 250 were invited to participate in the survey by sending them a link of the questionnaire (was prepared by using google forms) to e-mail or WhatsApp or by personal delivery. 155 of 250 middle school science teachers agreed to participate, thus the response rate was 62% of all study population. Table 3 presents the distribution of participants in the sample according to personal and professional background variables.

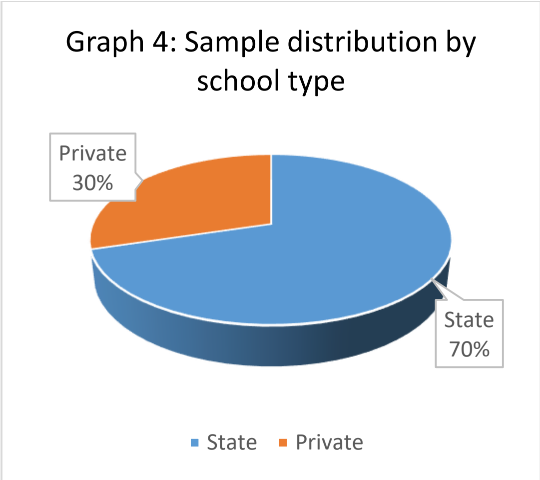
**Table 3.** Distribution of participants in the sample according to background variables

| Background variables | Categories | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 43 | 27.7 |
| | Female | 112 | 72.3 |
| | Total | 155 | 100 |
| Educational qualification | B.Ed./B.Sc. | 73 | 47.1 |
| | M.Ed./M.Sc. | 76 | 49.0 |
| | Ph.D. | 4 | 2.6 |
| | Other | 2 | 13 |
| | Total | 155 | 100 |
| Years of teaching experience | 1 - 5 years | 7 | 4.5 |
| | 6 - 10 years | 29 | 18.7 |
| | 11 - 15 years | 30 | 19.4 |
| | Above 15 years | 89 | 57.4 |
| | Total | 155 | 100 |
| School type | State | 109 | 70.3 |
| | Private | 46 | 29.7 |
| | Total | 155 | 100 |


Graph 1: Sample distribution by gender
Male , 28%
Female , 72%
Male
Female


Graph 2: Sample distribution by educational qualification
Other , 1%
Ph.D.,
B.Ed./B.Sc., 47%
M.Ed./M.Sc., 49%
B.Ed./B.Sc.
M.Ed./M.Sc.
Ph.D.
Other


Graph 3: Sample distribution by teaching experience
years, 5%
6 - 10 years, 19%
11 - 15 years, 19%
Above 15 years, 57%
1 - 5 years
6 - 10 years
11 - 15 years
Above 15 years




**Interview- Sampling Method.** Semi-structured interview had been conducted in order to elicit teachers' suggestions on how to improve meaningful learning and the obstacles they face in science teaching that hindered the implementation of meaningful learning. 20 science teachers in middle schools were randomly selected to represent the science teachers' population (see recommended sampling technique proposed by Birnbaum (1993) (pp. 239-242). The interview was conducted via telephone or face to face according to participant preference and convenience. Data were documented immediately during the interview.

## 6. Data Analysis

**Quantitative Statistical Analysis.** The quantitative analysis of the questionnaire was processed using the SPSS program. Results was based on statistical tests and tools such as: T-test to examine differences attributed to gender, educational qualification and type of school, Pearson coefficient to examine the correlation between beliefs and practice, Cronbach's Alpha to calculate the internal consistency of the items in the questionnaire, One-way ANOVA to examine differences attributed to the years of teaching experience, means and standard deviation, and percentages was calculated.

**Qualitative Data Analysis.** The content of the ideas emerged from the respondents' descriptions in the personal interviews had been analyzed according to the qualitative analysis by using the gradual coding process of: 1) Open coding: repeated statements will be identified and categorized. 2) Axial coding: identifying links on the vertical and horizontal axes at several levels of categories and sub-categories. 3)

Selective coding: the categories had been organized into a narrative line by focusing on a central category and the category that accompanies it (Shkedi, 2012). This process of analysis plays a role in the validation of content collected in the interview.

# CHAPTER V

# RESEARCH RESULTS

The current study intends to evaluate science teachers' beliefs in Arab middle schools in Northern Israel and their practice of specific pedagogical components which are crucial for promoting meaningful learning (ML). In addition, this study seeks to determine whether teachers’ beliefs have any relationship with their practice of these components. The researcher has also explored background factors, such as gender, years of teaching, educational qualification and school type, in order to determine whether they affect teachers' practice of the PCML. In addition, this study attempts to identify obstacles that might impede the implementation of meaningful learning, and conditions suggested by science teachers in middle schools to improve it. The findings of the study presented based on the research questions.

**1. The Quantitative Results of the Questionnaire.** The answers of the first three research questions were based on quantitative analyzing of data obtained from a questionnaire by using SPSS program. The findings of these questions described below.

### Findings of the first research question concerning: Science teachers' beliefs and practice in terms of specific pedagogical components of meaningful learning in Arab middle schools in northern Israel

To answer the first research question, teachers were asked to fulfill two sections of the questionnaire: the first one was regarding the *beliefs* toward pedagogical components essential for the promotion of meaningful learning and the second section was regarding the *practice* of these pedagogical components in their class. As introduced earlier, six pedagogical components of meaningful learning were examined in this study: *relevance* which is defined as the *constitutive* component of meaningful learning, and the other components such as *knowledge construction, critical thinking, feedback, learning by doing, and learning based on teaching* are defined as the *consecutive* components of meaningful learning. Participants' responses of the beliefs and practice sections were analyzed by calculating frequencies, percentages, means and standard deviations.

**Results of the Beliefs Section**: Means and standard deviations of teacher' responses on the extent of their *beliefs* toward the different pedagogical components of the meaningful learning (PCML) are presented in Table 4.

**Table 4:** Means and standard deviations of teacher's *beliefs* toward (PCML)

| Beliefs towards component | Mean | S.D. |
|---|---|---|
| Learning by doing (LBD) | 3.46 | 0.40 |
| Relevance (R) | 3.24 | 0.34 |
| Critical thinking (CT) | 3.19 | 0.45 |
| Feedback (FB) | 3.12 | 0.38 |
| Knowledge construction (KC) | 3.05 | 0.34 |
| Learning based on teaching (LBT) | 2.98 | 0.47 |
| **General beliefs** | **3.18** | **0.28** |

The findings in Table 4 indicate that the mean value of teachers' beliefs toward the whole pedagogical components of meaningful learning (PCML) was high and equal to 3.18 on the scale 1-4 with a standard deviation of 0.28. While the mean values of the teachers' beliefs toward these components ranged from 2.98 to 3.46. Findings also show relatively high mean values of teachers' beliefs of each of the PCML. The PCML were organized in table 4 in descending order according to the mean values of teachers' beliefs toward each component. The first rank was the *learning by doing* component with high mean value equal to 3.46 with a standard deviation of 0.4. Next was the *relevance* component with mean value equal to 3.24 with a standard deviation of 0.34. The *critical thinking* component also has a high mean value of 3.19 with a standard deviation of 0.45. It is followed by the mean value of teachers' beliefs toward the *feedback* component which was also high equal to 3.12 with a standard deviation of 0.38. The *knowledge construction* component has a high mean value of 3.05 with a standard deviation of 0.34. The *learning based on teaching* component has the lowest mean value of 2.98 with a standard deviation of 0.47.

The following tables present distributions, means with standard deviations of teachers' responses to the items of each PCML separately in the beliefs section.

**Table 5:** Distributions, means, and standard deviations of teachers' responses to the beliefs section items regarding the *relevance* component

| Item No. | Items related to beliefs towards 'Relevance' | Strongly agree | Agree | Disagree | Strongly disagree | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 1 | Prior knowledge of students does not play an important role when they learn new topic* | 7 (4.5%) | 35 (22.6%) | 68 (43.9%) | 45 (29.0%) | **2.03 (0.84)** |
| 2 | Students learn better when they know how the content can be applied in daily life | 100 (64.5%) | 51 (32.9%) | 4 (2.6%) | | **3.62 (0.54)** |
| 3 | Sharing students in selecting what topics or activities to be learned, increases their involvement in the learning process | 55 (35.5%) | 84 (54.2%) | 15 (9.7%) | 1 (0.6%) | **3.25 (0.65)** |
| 4 | Teacher should explain explicitly to the students why it is worthy for them to learn a particular topic | 67 (43.2%) | 80 (51.6%) | 7 (4.5%) | 1 (0.6%) | **3.37 (0.60)** |
| 5 | Students learns better when the learning activity focused on students' interest is close to his/her life | 107 (69.0%) | 46 (29.7%) | 2 (1.3%) | | **3.68 (0.50)** |
| 6 | Topics the students learn in classroom do not necessarily have to be related to the students' personal goals or future fields of work in which they are interested* | 22 (14.2%) | 75 (48.4%) | 55 (35.5%) | 3 (1.9%) | **2.75 (0.72)** |
| 7 | Teacher is supposed to provide challenging tasks that are adapted to the learner's unique abilities, that lead him/her to success and excellence | 91 (58.7%) | 61 (39.4%) | 2 (1.3%) | 1 (0.6%) | **3.56 (0.56)** |
| | **General** | | | | | **3.24 (0.34)** |

* Reversed question

The findings presented in Table 5 above show the teachers' responses to the beliefs section items in the questionnaire regarding the *relevance* component. About 73% of the respondents disagree with the item no. 1 which is a reversed item: "Prior knowledge of students does not play an important role when they learn new topic". The mean value for this item was low and equal to 2.03 on the scale 1-4 with a standard deviation of 0.84. In other words, the majority of teachers believe that students' prior knowledge plays an important role when they learn new content.

Regarding item no. 2, "Students learn better when they know how the content can be applied in daily life" it was found that the majority of the respondents, about 97%, expressed agreement on this item. It was also found that the mean value for this item was high and equal to 3.62 on the scale 1-4 with a standard deviation of 0.54. Regarding the item no. 3, "Sharing students in selecting what topics or activities to be learned, increases their involvement in the learning process", the majority of the respondents expressed their agreement for this item, and only 10% expressed disagreement. The mean value for this item was high and equal to 3.25 on a scale 1-4 with a standard deviation of 0.65. Item no. 4, "Teacher should explain explicitly to the students why it is worthy for them to learn a particular topic" also received a very high level of agreement about 95% of the respondents. It was also found that the mean value for this item was high and equal to 3.37 on scale 1-4 with a standard deviation of 0.60. Item no. 5, also received a high level of agreement about 99% of the respondents believe that "Student learns better when the learning activity focused on students' interest is close to his/her life". It was also found that the mean value for this item is high and equal to 3.68 on the 1-4 scale with a standard deviation of 0.50. The item no. 6 is a reversed item, "Topics the students learn in classroom do not necessarily have to be related to the students' personal goals or future fields of work in which they are interested". The positive formulation of this item received agreement only about 37% of the respondents. In other words, only 37% of the teachers believe that topics should be related to the students' personal goals or future fields of work in which they are interested. The mean value for this item equal to 2.75 on the scale of 1-4 with a standard deviation of 0.72. 98% of the respondents expressed agreement on the item no. 7 which is: "Teacher is supposed to provide challenging tasks that are adapted to the learner's unique abilities, that lead him/her to success and excellence". It was also found that the mean value for this item is high and equal to 3.56 on the scale of 1-4 with a standard deviation of 0.56.

**Table 6:** Distributions, means, and standard deviations of teachers' responses to the beliefs section items regarding the *knowledge construction* component

| Item No. | Items related to beliefs towards 'Knowledge construction' | Strongly agree | Agree | Disagree | Strongly disagree | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 8 | Students learn more effectively if they relate the material they learn to what they previously learned | 69 (44.5%) | 76 (49.0%) | 9 (5.8%) | 1 (0.6%) | **3.37 (0.63)** |
| 9 | Students can assess their understanding of a particular idea presented in the classroom, by rewriting and summarizing the idea in their own words | 54 (34.8%) | 87 (56.1%) | 14 (9.0%) | | **3.26 (0.61)** |
| 10 | Students can succeed in learning a content whether if they use high-order thinking processes or not* | 21 (13.5%) | 75 (48.4%) | 48 (31.0%) | 11 (7.1%) | **2.68 (0.80)** |
| 11 | Students learn best by finding solutions to problems themselves | 85 (54.8%) | 63 (40.6%) | 5 (3.2%) | 2 (1.3%) | **3.49 (0.63)** |
| 12 | Applying knowledge and skills learned in class in new contexts does not necessarily reflect student understanding* | 5 (3.2%) | 50 (32.3%) | 73 (47.1%) | 27 (17.4%) | **2.21 (0.76)** |
| | **General** | | | | | **3.05 (0.34)** |

The findings in Table 6 above show the teachers' responses to the beliefs section items in the questionnaire regarding the *knowledge construction* component. About 94% of respondents agreed on the item no. 8 which is: "Students learn more effectively if they relate the material they learn to what they previously learned". It was also found that the mean value for this item is high and equal to 3.37 on the scale 1 - 4 with a standard deviation of 0.63. Item no. 9, "Students can assess their understanding of a particular idea presented in the classroom, by rewriting and summarizing the idea in their own words" received a high level of agreement, so about 91% of the respondents agreed with the item. It was also found that the mean value for this item is high and equal to 3.26 on the scale 1-4 with a standard deviation of 0.61. Item no. 10, which is a reversed item, "Students can succeed in learning a content whether if they use high-order thinking processes or not". It was found that about 62% of the respondents agreed with this item, and it was also found that the mean value of this item was moderate and equal to 2.68 on scale 1-4 with a standard deviation of 0.8. This mean that the majority of teachers do not believe that using high-order thinking processes is essential to succeed in learning science. About 95% of teachers agreed with item no. 11, "Students learn best by finding solutions to problems themselves". The mean value for this item was high and equal to 3.49 on the scale 1-4 with a standard deviation of 0.63. Regarding item, no 12 which is a reversed question, "Applying knowledge and skills learned in class in new contexts does not necessarily reflect student understanding". About 65% disagreed with this item and the mean value of this item was low and equal to 2.21 on the scale 1 – 4 with a standard deviation of 0.76. In other words, the majority of respondents agreed that applying knowledge and skills learned in class in new contexts is necessarily reflect student understanding.

**Table 7:** Distributions, means, and standard deviations of teachers' responses to the beliefs section items regarding the *critical thinking* component

| Item No. | Items related to beliefs towards 'Critical thinking' | Strongly agree | Agree | Disagree | Strongly disagree | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 13 | Students are supposed to accept any knowledge presented in the class without giving them an opportunity to present doubt on this knowledge* | 7 (4.5%) | 38 (24.5%) | 69 (44.5%) | 41 (26.5%) | **2.07 (0.83)** |
| 14 | Teacher should allow students to give only one explanation or one solution to a problem* | 6 (3.9%) | 23 (14.8%) | 68 (43.9%) | 58 (37.4%) | **1.85 (0.81)** |
| 15 | Students should accept any information received from any source without the need to assess its trustworthiness * | 3 (1.9%) | 16 (10.3%) | 60 (38.7%) | 76 (49%) | **1.65 (0.74)** |
| 16 | Evidence gathered to support a particular claim should not be discussed whether it support the claim or not* | 3 (1.9%) | 14 (9.0%) | 71 (45.8%) | 67 (43.2%) | **1.70 (0.72)** |

| Item No. | Items related to beliefs towards 'Critical thinking' | Strongly agree | Agree | Disagree | Strongly disagree | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 17 | It is sufficient to present the knowledge acquired by the students in one specific and unique way* | 5 (3.2%) | 14 (9.0%) | 70 (45.2%) | 66 (42.6%) | **1.73 (0.76)** |
| 18 | Students are supposed to provide explanations and reasons why their point of view is the right one | 73 (47.1%) | 75 (48.4%) | 7 (4.5%) | | **3.43 (0.58)** |
| 19 | Students are supposed to bring contradictory evidence to ideas presented by others | 26 (16.8%) | 85 (54.8%) | 41 (26.5%) | 3 (1.9%) | **2.86 (0.70)** |
| 20 | Students should draw and justify conclusions from the research work they did before the teacher do so | 55 (35.5%) | 81 (52.3%) | 16 (10.3%) | 3 (1.9%) | **3.21 (0.70)** |
| | **General** | | | | | **3.19 (0.45)** |

The findings in Table 7 show the teachers' responses to the beliefs section items in the questionnaire regarding the *critical thinking* component. Regarding the item no. 13 which is a reversed question, "Students are supposed to accept any knowledge presented in the class without giving them an opportunity to present doubt on this knowledge", it was found that only 29% of the teachers agreed with the item, and the mean value for this item was low and equal to 2.07 on the scale 1-4 with a standard deviation of 0.83. In other words, most teachers (71%) agreed that students can present their doubt on any knowledge presented in class. Item no 14, which is also a reversed question, "Teacher should allow students to give only one explanation or one solution to a problem". This item received a low percentage of agreement, equal to about 19%. The mean value for this item was low and equal 1.85 with a standard deviation of 0.81. In other words, most teachers (81%) agreed that students should be allowed to give more than one solution or explanation for each problem. This mean that the teachers believe that students should have more than one point of view when they give explanations or solutions for problems or phenomena.

For item no. 15, which is a reversed item, "Students should accept any information received from any source without the need to assess its trustworthiness", this item received a very low level of agreement equal to about 12%. It was also found that the mean value for this item is low and equal to 1.65 on the scale of 1 – 4 with a standard deviation of 0.74. In other words, most teachers (88%) agreed that students should evaluate the trustworthiness of any information they receive from any resource. The item no. 16, which is also a reversed item, "Evidence gathered to support a particular claim should not be discussed whether it support the claim or not", received very low level of agreement which is equal to about 11%. It found that the mean value of this item was low and equal to 1.70 on the 1-4 scale with a standard deviation of 0.72. In other words, most teachers (89%) agreed that a discussion is needed to assess whether the evidence was gathered support a particular claim or not.

Item no. 17, which is a reversed item, "It is sufficient to present the knowledge acquired by the students in one specific and unique way" received a low percentage of agreement of about 12%. It was also found that the mean value for this item is low and equal to 1.73 on the scale 1-4 with a standard deviation of 0.76. In other words, the majority of teachers (88%) agreed that students are supposed to present the knowledge they have acquired in different ways. Item no.18, "Students are supposed to provide explanations and reasons why their point of view is the right one" received a high degree of agreement equal to about 96% and the mean value is high and equal 3.43 with a standard deviation of 0.58. Item no. 19,"Students are supposed to bring contradictory evidence to ideas presented by others", received a level of agreement equal to about 72% of the teachers. The mean value of this item was 2.86 with a standard deviation of 0.70. Regarding item no. 20, "Students should draw and justify conclusions from the research work they did before the teacher does so", it was found that about 88% of the teachers agreed with the item, and the mean value is equal to 3.21 on the scale 1-4 with a standard deviation of 0.70.

**Table 8:** Distributions, means, and standard deviations of teachers' responses to the beliefs section items regarding the *feedback* component

| Item No. | Items related to beliefs towards 'Feedback' | Strongly agree | Agree | Disagree | Strongly disagree | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 21 | Learning becomes more effective when students assess personally their learning progress | 83 (53.5%) | 59 (38.1%) | 12 (7.7%) | 1 (0.6%) | **3.45 (0.67)** |
| 22 | Students will be more successful if they use feedback from self-assessment to make improvement in their learning performance | 77 (49.7%) | 69 (44.5%) | 9 (5.8%) | | **3.44 (0.60)** |
| 23 | Assessment of students' learning outcomes should be based upon predefined criteria/rubrics | 85 (54.8%) | 59 (38.1%) | 11 (7.1%) | | **3.48 (0.63)** |
| 24 | Feedback from ongoing assessment plays a problematic role in designing the learning activities* | 23 (14.8%) | 69 (44.5%) | 51 (32.9%) | 12 (7.7%) | **2.66 (0.82)** |
| 25 | Assessment of students' understanding should be performed only in the end of teaching the unit* | 12 (7.7%) | 39 (25.2%) | 71 (45.8%) | 33 (21.3%) | **2.19 (0.86)** |
| 26 | It is a waste of time to give detailed written feedback on students' work in addition to marking* | 8 (5.2%) | 14 (9.0%) | 62 (40.0%) | 71 (45.8%) | **1.74 (0.83)** |
| 27 | Learning becomes more effective when teacher provides immediate feedback during their working on a task | 46 (29.7%) | 84 (54.2%) | 19 (12.3%) | 6 (3.9%) | **3.10 (0.75)** |
| **General** | | | | | | **3.12 (0.38)** |

The findings in Table 8 show the teachers' responses to the beliefs section items in the questionnaire regarding the *feedback* component. Item no. 21, "Learning becomes more effective when students assess personally their learning progress" received high level of agreement, about 92% of the respondents, and the mean value was high and equal to 3.45 with a standard deviation of 0.67. Item no. 22 "Students will be more successful if they use feedback from self-assessment to make improvement in their learning performance", received high mean value equal to 3.44 with a standard deviation of 0.60. The majority of respondents about 94%, agreed with this item. Item no. 23, "Assessment of students' learning outcomes should be based upon predefined criteria/rubrics" also received high level of agreement, about 93%, and received mean value equal to 3.48 with a standard deviation of 0.63. Item no. 24, which is a reversed item, "Feedback from ongoing assessment plays a problematic role in designing the learning activities", received about 60% of agreement and the mean value was 2.66 with a standard deviation of 0.82. In addition, item no. 25, which is a reversed item, "Assessment of students' understanding should be performed only in the end of teaching the unit" received only about one-third (33%) of agreement. The mean value was low and equal to 2.19 with a standard deviation of 0.86. In other words, the majority of teachers (67%) agreed that the assessment of students' understanding should not be performed only at the end of the unit's instruction, it should be done along all the learning process. Item no. 26, which is a reversed item, "It is a waste of time to give detailed written feedback on students' work in addition to marking", received a very low agreement equal to about 14%, and the mean value for this item is very low and equal to 1.74 with a standard deviation of 0.83. In other words, most teachers (86%) agreed to provide written feedback on student work in addition to marking, and this is not a waste of time for them. Item no. 27 "Learning becomes more effective when teacher provides immediate feedback during their work on a task" received high level of agreement. About 84% of the teachers agreed that providing immediate feedback to the students while they do their work, makes learning more effective. It was found that the mean value for this item is 3.10 with standard deviation of 0.75.

**Table 9:** Distributions, means, and standard deviations of teachers' responses to the beliefs section items regarding the *learning by doing* component

| Item No. | Items related to beliefs towards 'Learning by doing' | Strongly agree | Agree | Disagree | Strongly disagree | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 28 | Learning a topic by doing (e.g. conducting experiments, building models or products, making measurements, conducting inquiry, project-based learning, etc.) leads to a better understanding of this topic | 120 (77.4%) | 34 (21.9%) | 1 (0.6%) | | **3.77 (0.44)** |
| 29 | Student will learn more effectively in learning by doing, compared to learning by listening to a teacher's lecture | 96 (61.9%) | 48 (31.0%) | 10 (6.5%) | 1 (0.6%) | **3.54 (0.65)** |
| 30 | Learning by doing makes it more difficult for the student to learn the content* | 8 (5.2%) | 19 (12.3%) | 63 (40.6%) | 65 (41.9%) | **1.81 (0.85)** |
| 31 | Having to work within learning by doing invest more time and efforts, compared to learning by listening to a teacher's lecture | 64 (41.3%) | 67 (43.2%) | 20 (12.9%) | 4 (2.6%) | **3.23 (0.77)** |
| 32 | Student who learns by doing will understand the material faster, compared to learning it by listening to a teacher's lecture | 96 (61.9%) | 54 (34.8%) | 5 (3.2%) | | **3.59 (0.56)** |
| | **General** | | | | | **3.46 (0.40)** |

The findings in Table 9 show the teachers' responses to the beliefs section items in the questionnaire regarding the *learning by doing* component. Item no. 28, "Learning a topic by doing (e.g. conducting experiments, building models or products, making measurements, conducting inquiry, project-based learning, etc.) leads to a better understanding of this topic" received agreement of about 99% of the teachers. The mean value of the level of agreement was particularly high, and was 3.77 with standard deviation of 0.44. Item no. 29, "Student will learn more effectively in learning by doing, compared to learning by listening to a teacher's lecture" received about 93% agreement, the mean value was high and equal to 3.54 with standard deviation of 0.65. About 18% of the teachers expressed agreement for the item no. 30, which is a reversed item, "Learning by doing makes it more difficult for the student to learn the content". The mean value of this item was 1.81 which is relatively low with a standard deviation is 0.85. This means most teachers (82%) believe that it easier for the student to learn content by doing. About 85% of the teachers agreed to the item no. 31which is "Having to work within learning by doing invest more time and efforts compared to learning by listening to a teacher's lecture". The mean value is 3.23 and standard deviation of 0.77. In addition, about 97% of the teachers expressed full agreement on the item no 32 that is "Student who learns by doing will understand the material faster, compared to learning it by listening to a teacher's lecture". The mean value of this item is high 3.59 with a standard deviation of 0.56.

**Table 10:** Distributions, means, and standard deviations of teachers' responses to the beliefs section items regarding the *learning based on teaching* component

| Item No. | Items related to beliefs towards 'Learning based on teaching' | Strongly agree | Agree | Disagree | Strongly disagree | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 33 | Student who learns new content by himself/herself in order to teach it to his/her classmates will better understand this content, compared to learning it by listening to a teacher's lecture | 70 (45.2%) | 64 (41.3 %) | 19 (12.3%) | 2 (1.3%) | **3.30 (0.73)** |
| 34 | Student who learns new content by himself/herself in order to teach it to his/her classmates learns more effectively this content, compared to learning it by listening to a teacher's lecture | 62 (40.0%) | 66 (42.6 %) | 22 (14.2%) | 5 (3.2%) | **3.19 (0.80)** |
| 35 | Student who learns new content by himself/herself in order to teach it to his/her classmates, makes it more difficult for him/her to learn the content* | 8 (5.2%) | 28 (18.1 %) | 85 (54.8%) | 34 (21.9%) | **2.06 (0.78)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **36** | Student who learns new content by himself/herself in order to teach it to his/her classmates, invest more time and efforts, compared to learning by listening to a teacher's lecture | 64 (41.3%) | 69 (44.5 %) | 22 (14.2%) | | **3.27 (0.70)** |
| 37 | Student who learns new content by himself in order to teach it to his/her classmates, will understand the material faster, compared to learning it by listening to a teacher's lecture | 59 (38.1%) | 49 (31.6 %) | 44 (28.4%) | 3 (1.9%) | **3.06 (0.86)** |
| | **General** | | | | | **2.98 (0.47)** |

The findings in Table 10 show the teachers' responses to the beliefs section items in the questionnaire regarding the *learning based on teaching* component. About 87% of the teachers agreed with the item no. 33, "Student who learns new content by himself/herself in order to teach it to his/her classmates will better understand this content, compared to learning it by listening to a teacher's lecture". The mean value for this item is relatively high and equal to 3.3 with a standard deviation of 0.73. The item no. 34, "Student who learns new content by himself/herself in order to teach it to his/her classmates learns more effectively this content, compared to learning it by listening to a teacher's lecture" received about 83% of agreement. The mean value of this item was 3.19 with a standard deviation of 0.80. Item no. 35 which is a reversed item, "Student who learns new content by himself/herself in order to teach it to his/her classmates, makes it more difficult for him/her to learn the content", only 23% of the teachers agreed with this item and the mean value was 2.06 with a standard deviation of 0.78. This mean that the majority of teachers (77%) agreed that it is not difficult for the student to learn new content by himself. Item no. 36, "Student who learns new content by himself/herself in order to teach it to his/her classmates invest more time and efforts, compared to learning by listening to a teacher's lecture", received agreement about 86% of the whole teachers and received mean value 3.27 and a standard deviation of 0.70. Item no 37, "Student who learns new content by himself/herself in order to teach it to his/her classmates, will understand the material faster, compared to learning it by listening to a teacher's lecture" has about 70% agreement. This item received relatively high mean value of 3.06 and standard deviation 0.86.

**Summary of the Findings of the Beliefs Section.** Based on these findings, it can be concluded that teachers hold high positive beliefs towards meaningful learning and its various components (dimensions) with a general mean value of 3.18 and standard deviation of 0.28. With regard to the *relevance* component, which has mean value of 3.24, teachers believe that students' prior knowledge plays an important role when they learn a new topic, and students learn better when they know how the content applied in daily life, and that sharing students in selecting what topics under study or what activities increase their involvement in the learning process, and that student learns better when the learning activity focused on their interest is close to their life. Teachers also believe that subjects that students learn in the classroom should be related to the personal goals of the students or future areas of work they are interested in, and that teacher is supposed to provide challenging tasks adapted to the learner's unique abilities that will lead him/her to success and excellence. Teachers believe that they should explain explicitly to the students why it is worthy for them to learn a particular topic.

Regarding the component *knowledge construction* which received mean value of 3.05, teachers expressed support and positive attitudes towards the importance of *knowledge construction*. Teachers believe that students learn more effectively if they relate what they learn to what they previously learned, and that students can assess their understanding of a particular idea presented in a class by rewriting and summarizing the idea in their own words, and that students learn best by finding solutions to problems themselves, and that applying knowledge and skills learned in class in new contexts reflect student understanding.

The *critical thinking* component also received high mean value of 3.19. The teachers expressed their support and positive attitudes towards the importance of critical thinking. Teachers' responses to questions for this component suggest that students should not accept any knowledge presented in the class without giving them an opportunity to present doubt on this knowledge, and student is supposed to investigate a problem from different points of view and give more than one explanation or one solution. Also students should not accept any information obtained from any source without assessing its trustworthiness, and that evidence gathered to support a particular claim should be discussed whether it support the claim or not. Teachers also believe that it is not enough to present the knowledge acquired by students in a single, defined way, and that the students are supposed to provide explanations and reasons why their point of view is the right one. Teachers also believe that students are supposed to bring contradictory evidence to ideas presented by others, that students should draw and justify conclusions from the research work they did before the teacher do that.

The teachers expressed their support and positive attitudes towards the importance of *feedback* and its necessity to the students' learning process. This component received a mean value of 3.12. Teachers believe that learning is more effective when students personally assess their learning progress, and students will be more successful if feedback is used as a self-assessment tool to improve their learning performance, and assessing students' learning outcomes should be based on predefined criteria/ rubrics, and the students' understanding should be assessed not only at the end of the unit's teaching it should be an ongoing assessment. In addition, most teachers agree to provide written feedback on students' work in addition to marking, and they believe that learning is more effective when the teacher provides immediate feedback to students during their work on a task.

Teachers also expressed positive support for the importance of *learning by doing* to the students' learning process. This component received mean value of 3.46. Teachers believe that learning by doing (e.g., experimenting, constructing models or products, making measurements, conducting inquiry, using project-based learning, etc.) leads to better understanding, and students will learn more effectively in learning by doing comparing learning by listening to a teacher's lecture, and learning by doing is not a way that makes it difficult for the student to learn the content, and learning by doing needs to spend more time and effort than learning by a teacher's lecture, and a student who learns by doing will understand the material learned faster.

Regarding the *learning based on teaching* component, the mean value was 2.98. Teachers believe that a student who learns new content in order to teach it to his/her classmates will better understand this content, and learns more effectively this content, and it is not difficult for the student to learn new content by himself to teach to his/her classmates, *learning based on teaching* invests more time and effort, and a student who learns new content in order to teach it to his/her classmates will understand the material faster than learning it by listening to a teacher's lecture.

**Results of the Practice Section**: Means and standard deviations of teachers' responses on the frequency of their *practice* of the different pedagogical components of the meaningful learning are presented in Table 11.

**Table 11:** Means and standard deviations of teacher's *practice* of pedagogical components of meaningful learning (PCML)

| Practice of component | Mean | S.D. |
|---|---|---|
| Learning by doing (LBD) | 3.24 | 0.77 |
| Critical thinking (CT) | 3.17 | 0.57 |
| Feedback (FB) | 2.98 | 0.58 |
| Learning based on teaching (LBT) | 2.95 | 0.81 |
| Knowledge construction (KC) | 2.92 | 0.55 |
| Relevance (R) | 2.75 | 0.51 |
| **General practice** | **2.97** | **0.47** |

The findings in Table 11 above indicate that the mean value of the frequency of teachers' practice of the whole pedagogical component of meaningful learning (PCML) was high and equal to 2.97 in the scale 1-4 with a standard deviation of 0.47. The mean values of teachers' practice of these components ranged from 2.75 to 3.24. Findings also show relatively high mean value of teachers' practice of each of the PCML. The PCML were organized in table 11 in descending order according to the mean value of teachers' practice of each component. The first rank was the *learning by doing* component with high mean value of 3.24 and a standard deviation of 0.77. The next was the *critical thinking* component with high mean value of 3.17 with a standard deviation of 0.57. The *feedback* component also has high mean value of 2.98 with a standard deviation of 0.58. *Learning based on teaching* component has a mean value of 2.95 with a standard deviation of 0.81. The mean value of teachers' practice of *knowledge construction* component was 2.92 with a standard deviation of 0.55. The lowest mean value was related to *relevance* component; it was 2.75 with standard deviation of 0.51.

The following tables describe the distributions, means, and standard deviations of the teachers' responses to the practice section items in the questionnaire to each of the pedagogical components of meaningful learning (PCML).

**Table 12:** Distributions, means, and standard deviations of teachers' responses to the practice section items regarding the *relevance* component

| Item No. | Items related to practice of 'Relevance' | Always 4 | Frequently 3 | Occasionally 2 | Never 1 | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 1 | A new subject learned in the classroom, is based on prior knowledge that the student has | 35 (22.6%) | 62 (40%) | 44 (28.4%) | 14 (9.0%) | **2.76 (0.91)** |
| 2 | Students are given the opportunity to apply the knowledge or skills they have learned in the classroom in situations related to daily life or to real world outside the school | 29 (18.7%) | 83 (53.5%) | 38 (24.5%) | 5 (3.2%) | **2.88 (0.74)** |
| 3 | Students are given the opportunity to decide what topics they are going to learn and which learning activities they will do | 3 (1.9%) | 22 (14.2%) | 68 (43.9%) | 62 (40.0%) | **1.78 (0.76)** |
| 4 | I state explicitly why it is important to the students to learn a particular topic | 68 (43.9%) | 65 (41.9%) | 22 (14.2%) | | **3.30 (0.70)** |
| 5 | I give a learning activity or a task based on the students' personal interest | 33 (21.3%) | 75 (48.4%) | 46 (29.7%) | 1 (0.6%) | **2.90 (0.73)** |
| 6 | Students are given the opportunity to learn many things in the classroom that are suitable for their personal goals or future student careers | 31 (20.0%) | 59 (38.1%) | 58 (37.4%) | 7 (4.5%) | **2.74 (0.83)** |
| 7 | Students are given various tasks and learning activities adapted to their abilities and pace of learning | 32 (20.6%) | 78 (50.3%) | 39 (25.2%) | 6 (3.9%) | **2.88 (0.78)** |
| | **General** | | | | | **2.75 (0.51)** |

The findings in Table 12 show the teachers' responses to the practice section items in the questionnaire regarding the *relevance* component. About two-thirds (63%) of the teachers reported that they implement frequently/always what is described in the first item which is: "A new subject learned in the classroom, is based on prior knowledge that the student has". It was found that the mean value of implementing this activity in the science lessons is moderate and equal to 2.76 on the scale 1-4 with a standard deviation of 0.91. About 72% of the participants implement frequently/always the second item that is: "Students are given the opportunity to apply the knowledge or skills they have learned in the classroom in situations related to daily life or to real world outside the school". It was found that the mean value of implementing this activity in the science lessons is moderate and equal to 2.88 with a standard deviation of 0.74. With regard to the item no. 3, only about 16% of the teachers practice frequently/always the activity, "Students are given the opportunity to decide what topics they are going to learn and which learning activities they will do" and it was found that the mean value of implementing this activity in the science lessons was low and equal to 1.78 with a standard deviation of 0.76. In other words, the frequency to which the students are given the opportunity to decide what to learn and which learning activities they will do was very low. About 85% of the respondents apply frequently/always what is described in item no. 4 which is: "I state explicitly why it is important to the students to learn a particular topic", the mean value of implementing this activity in the science lessons was high and equal to 3.30 with a standard deviation of 0.70. In addition, about two-thirds (70%) of teachers apply frequently/always what is described in item no. 5 refers to "I give a learning activity or a task, based on the students' personal interest". The mean value for implementing this activity was 2.90 with standard deviation of 0.73. About 58% of the teachers practice frequently/always the opportunity described in the item no. 6. This item refers to "Students are given the opportunity to learn many things in the classroom that are suitable for their personal goals or future careers". The mean value of implementing this activity in the science lessons was moderate and equal to 2.74 with a standard deviation of 0.83. About 71% of teachers apply frequently/always what is described in item no. 7. This item refers to "Students are given various tasks and learning activities adapted to their abilities and pace of learning". The mean value of implementing this activity in the science lessons was moderate and equal to 2.88 with a standard deviation of 0.78.

**Table 13:** Distributions, means, and standard deviations of teachers' responses to the practice section items regarding the *knowledge construction* component

| Item No. | Items related to practice of 'Knowledge construction' | Always | Frequently | Occasionally | Never | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 8 | Students are given the opportunity to make connections between concepts they already know and concepts that will be learned in the future | 46 (29.7%) | 85 (54.8%) | 23 (14.8%) | 1 (0.6%) | **3.14 (0.67)** |
| 9 | Students are given the opportunity to rewrite or summarize the main ideas from books or other sources using their own words | 24 (15.5%) | 68 (43.9%) | 58 (37.4%) | 5 (3.2%) | **2.72 (0.76)** |
| 10 | Students are given the opportunity to apply higher order thinking processes when they learn a certain content | 38 (24.5%) | 84 (54.2%) | 28 (18.1%) | 5 (3.2%) | **3.00 (0.74)** |
| 11 | Students are given the opportunity to investigate real problems themselves and think of solutions to these problems before the teacher shows them how they are resolved | 37 (23.9%) | 61 (39.4%) | 53 (34.2%) | 4 (2.6%) | **2.85 (0.81)** |
| 12 | Students are given the opportunity to apply the knowledge and skills they have acquired in class to new problems and situations | 33 (21.3%) | 72 (46.5%) | 50 (32.3%) | | **2.89 (0.73)** |
| | **General** | | | | | **2.92 (0.55)** |

The findings in Table 13 show the teachers' responses to the practice section items in the questionnaire regarding the *knowledge construction* component. Item no 8 refers to "Students are given the opportunity to make connections between concepts they already know and concepts that will be learned in the future". About 85% of the teachers apply frequently/always this activity, and the mean value of implementing this activity in the science lessons was 3.14 with a standard deviation of 0.67. Regarding the item, no. 9 refers to "Students are given the opportunity to rewrite or summarize the main ideas from books or other sources using their own words", it was found that about 60% of the teachers apply frequently/always the activity described in this item, and the mean value of implementing this activity in the science lessons was moderate and equal to 2.72 with a standard deviation of 0.76.

About 79% of the teachers apply frequently/always what is described in item no. 10 which is "Students are given the opportunity to apply higher order thinking processes when they learn a certain content". The mean value of implementing this activity in the science lessons was 3.00 with a standard deviation of 0.74. About 63% of teachers apply frequently/always the activity in item no. 11, this item refers to "Students are given the opportunity to investigate real problems themselves and think of solutions to these problems before the teacher shows them how they are resolved". The mean value of implementing this activity in the science lessons was moderate and equal to 2.85 with a standard deviation of 0.81. In addition, about 68% of the teachers implement frequently/always the activity in item no. 12 which is "Students are given the opportunity to apply the knowledge and skills they have acquired in class to new problems and situations", the mean value of implementing this activity in the science lessons was found moderate and equal to 2.89 with a standard deviation of 0.73.

**Table 14:** Distributions, means, and standard deviations of teachers' responses to the practice section items regarding the *critical thinking* component

| Item No. | Items related to practice of 'Critical thinking' | Always | Frequently | Occasionally | Never | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 13 | Students are given the opportunity to doubt/ask about information, that is confusing them, for clarification | 92 (59.4%) | 52 (33.5%) | 8 (5.2%) | 3 (1.9%) | **3.50 (0.69)** |
| 14 | Students are given the opportunity to present ideas from different points of view, such as to present various options to solve a problem | 81 (52.3%) | 63 (40.6%) | 11 (7.1%) | | **3.45 (0.63)** |
| 15 | Students are given the opportunity to evaluate the | 47 (30.3%) | 63 (40.6%) | 38 (24.5%) | 7 (4.5%) | **2.97 (0.86)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | reliability of sources of information they used | | | | | |
| 16 | Students are given the opportunity to judge if a given evidence supports a certain claim | 41 (26.5%) | 75 (48.4%) | 37 (23.9%) | 2 (1.3%) | **3.00 (0.75)** |
| 17 | Students are given the opportunity to interpret data in various ways such as: images, charts, graphs and tables | 60 (38.7%) | 76 (49.0%) | 19 (12.3%) | | **3.26 (0.67)** |
| 18 | Students are given the opportunity to present arguments and provide reasons to justify them | 46 (29.7%) | 72 (46.5%) | 35 (22.6%) | 2 (1.3%) | **3.05 (0.76)** |
| 19 | Students are given the opportunity to give evidence that disconfirms other's ideas | 38 (24.5%) | 77 (49.7%) | 38 (24.5%) | 2 (1.3%) | **2.97 (0.74)** |
| 20 | Students are given the opportunity to draw and justify conclusions from a research work, in which they have participated | 62 (40.0%) | 60 (38.7%) | 30 (19.4%) | 3 (1.9%) | **3.17 (0.80)** |
| | | **General** | | | | **3.17 (0.57)** |

The findings in Table 14 show the teachers' responses to the practice section items in the questionnaire regarding the *critical thinking* component. The majority of the teachers, about 93%, apply frequently/always the activity described in item no. 13 which is: "Students are given the opportunity to doubt/ask about information, that is confusing them, for clarification". A high mean value of practicing this activity in the science lessons was 3.50 on the scale 1-4 with a standard deviation of 0.69. In addition, a high percentage of 93% of teachers apply frequently/always the activity described in item no. 14 which is "Students are given the opportunity to present ideas from different points of view, such as to present various options to solve a problem". A high mean value of implementing this activity in the science lessons was found and it is 3.45 with a standard deviation of 0.63. With regard to item no. 15 which is "Students are given the opportunity to evaluate the reliability of sources of information they used", it was found that 71% of the teachers implement frequently/always the activity described in the item, the mean value of implementing this activity in the science lessons was relatively high 2.97 with a standard deviation of 0.86. The item no. 16 states that "Students are given the opportunity to judge if a given evidence supports a certain claim". This item received high percentage of about 75% of respondents who apply frequently/always the activity described in the item with a high mean value of its implementation was 3.00 with a standard deviation of 0.75. Item no. 17 refers to "Students are given the opportunity to interpret data in various ways such as images, charts, graphs and tables" was received percentage about 88% of the teachers who applied frequently/always the activity described in the item, and its mean value of implementing was high of 3.26 with standard deviation of 0.67. Item no 18 refers to "Students are given the opportunity to present arguments and provide reasons to justify them" has gained a high percentage of 76% of the teachers, who apply frequently/always the activity described in the item, and its mean value of practice was high and equal 3.05 with standard deviation of 0.76. About 75% apply frequently/always the activity described in item no 19 that is "Students are given the opportunity to give evidence that disconfirms other's ideas". The mean value of practicing this activity in the science lessons was found high and it is 2.97 with a standard deviation of 0.74. With regard to item no 20 that is "Students are given the opportunity to draw and justify conclusions from a research work, in which they have participated", it has gained about 80% of teachers who apply frequently/always the activity described in the item. The mean value of practicing this activity was high and equal to 3.17 with standard deviation of 0.8.

**Table 15:** Distributions, means, and standard deviations of teachers' responses to the practice section items regarding the *feedback* component

| **Item No.** | **Items related to practice of 'Feedback'** | **Always** | **Frequently** | **Occasionally** | **Never** | **Mean (S.D.)** |
|---|---|---|---|---|---|---|
| 21 | Students are given the opportunity to assess their own learning progress | 33 (21.3%) | 60 (38.7%) | 54 (34.8%) | 8 (5.2%) | **2.76 (0.85)** |
| 22 | Students use feedback based on self-assessment to promote and improve their learning | 21 (13.5%) | 69 (44.5%) | 47 (30.3%) | 18 (11.6%) | **2.60 (0.87)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 23 | Assessment of students' learning outcomes is based upon predefined criteria/rubrics | 68 (43.9%) | 63 (40.6%) | 18 (11.6%) | 6 (3.9%) | **3.25 (0.81)** |
| 24 | Learning activities are mainly shaped based upon feedback from ongoing assessment processes | 41 (26.5%) | 69 (44.5%) | 39 (25.2%) | 6 (3.9%) | **2.94 (0.82)** |
| 25 | Students' understanding is assessed continuously during and in the end of the learning process | 58 (37.4%) | 74 (47.7%) | 23 (14.8%) | | **3.23 (0.69)** |
| 26 | Students are given detailed written feedback on their work in addition to marking | 57 (36.8%) | 61 (39.4%) | 31 (20.0%) | 6 (3.9%) | **3.09 (0.85)** |
| 27 | When students perform a task they receive immediate feedback from a teacher | 46 (29.7%) | 63 (40.6%) | 43 (27.7%) | 3 (1.9%) | **2.98 (0.81)** |
| | **General** | | | | | **2.98 (0.58)** |

The findings in Table 15 show the teachers' responses to the practice section items in the questionnaire regarding the *feedback* component. 60% of the teachers reported that students frequently/always perform the activity described in item 21 which is "Students are given the opportunity to assess their own learning progress". In addition, 58% of the teachers reported that students frequently/always perform the activity described in item no. 22 which is "Students use feedback based on self-assessment to promote and improve their learning". The two items had a moderate mean value of 2.76 with a standard deviation of 0.85 and 2.6 with a standard deviation of 0.87 respectively. About 85% of the teachers reported that they frequently/always perform the activity described in item no. 23 which is: "Assessment of students' learning outcomes is based upon predefined criteria/rubrics". The mean value of this item is 3.25 with a standard deviation of 0.81. Regarding item no. 24, "Learning activities are mainly shaped based upon feedback from ongoing assessment processes", it was found that 71% of the teachers reported that they frequently/always perform the activity described in this item. The mean value of this item is 2.94 with a standard deviation of 0.82. About 85% of the teachers practice frequently/always the activity described in item no. 25 refers to "Students' understanding is assessed continuously during and in the end of the learning process". The item no. 25 has achieved a mean value of 3.23 with a standard deviation of 0.69 which is relatively high on the scale 1 - 4. About 76% of the teachers implement frequently/always the item no. 26 which is "Students are given detailed written feedback on their work in addition to marking" and found that the mean value of implementation of the activity described in this item is 3.09 with a standard deviation of 0.85. About 70% of the teachers reported that the activity described in item no. 27 is applied frequently/always. This item refers to "When students perform a task they receive immediate feedback from a teacher". The item no. 27 has achieved a mean value that is 2.98 with a standard deviation of 0.81.

**Table 16:** Distributions, means, and standard deviations of teachers' responses to the practice section items regarding the *learning by doing* component

| Item No. | Items related to practice of 'Learning by doing' | Always | Frequently | Occasionally | Never | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 28 | During the last year the students were given the opportunity to learn by doing (e.g. conducting experiments, building models or products, taking measurements, conducting research, using project based learning and so on) | 64 (41.3%) | 68 (43.9%) | 19 (12.3%) | 4 (2.6%) | **3.24 (0.77)** |

**Table 17:** Distributions, means, and standard deviations of teachers' responses to the practice section items regarding the *learning based on teaching* component

| Item No. | Items related to practice of 'Learning based on teaching' | Always | Frequently | Occasionally | Never | Mean (S.D.) |
|---|---|---|---|---|---|---|
| 29 | During the last year the students were given the opportunity to teach or guide other students or the whole class or to present a subject or problem that they learned themselves | 42 (27.1%) | 68 (43.9%) | 40 (25.8%) | 5 (3.2%) | **2.95 (0.81)** |

The findings which are presented in Table 16 and Table 17 show the teachers' responses to the practice section items regarding the *learning by doing and learning based on teaching* components respectively. Refers to the item 28, about 85% of the teachers reported that during the last year students were given the opportunity to learn by doing (e.g. conducting experiments, building models or products, taking measurements, conducting research, using project based learning and so on) and it received a high mean value of implementation of 3.24 with a standard deviation of 0.77. Regarding item 29, 71% of the teachers reported that during the last year the students were given the opportunity to teach or guide other students or the whole class or to present a subject or problem that they learned themselves. The mean value of implementation this activity in science lessons was 2.95 with a standard deviation of 0.81.

**Summary of the findings of the Practice Section.** Based on these findings, we can conclude that the readiness and the level of willingness to implement different pedagogical components of meaningful learning by science teachers is in a level with a general mean value of 2.97. In *relevance* component which has mean value of 2.75, the majority of teachers think that a new subject learned in the classroom is based on prior knowledge that the student has, and that students are given the opportunity to apply the knowledge or skills they have learned in the classroom in other situations related to daily life or to real world outside the school, and that teachers state explicitly why it is important to the students to learn a particular topic and they give a learning activity or a task based on the students' personal interest, personal goals or their future careers and that students receive various learning tasks and activities depending on their ability and pace of learning.

Regarding the *knowledge construction* component which has mean value of 2.92, it was found that the majority of teachers think that students are given the opportunity to make connections between concepts they already know and concepts will be learned in the future and that students are given the opportunity to apply higher order thinking processes when they learn certain content. In addition, teachers think that students are given an opportunity to investigate real problems themselves and to think about solutions to these problems before the teacher shows them how they are resolved, and that students are given the opportunity to apply the knowledge and skills they have acquired in the classroom to a new problems and situations.

The perceived practice of the *critical thinking* component has mean value of 3.17, and the majority of teachers think that students were given the opportunity to ask about information that confuse them for clarification, and were asked to present their arguments and provide reasons to justify them. In addition, teachers think that students got the chance to present ideas from different points of view, such as to present various options to solve a problem, and students are given an opportunity to evaluate the reliability of sources of information they used, and that students are given the opportunity to judge if a given evidences support a certain claim and they are given the opportunity to interpret data in various ways such as images, charts, graphs and tables. In addition, students are given the opportunity to give evidence that disconfirms other's ideas. Teachers also reported that students are given the opportunity to draw and justify conclusions from a research work, in which they have participated.

Regarding the *feedback* component which has mean value of 2.98, the majority of teachers think that students are given the opportunity to assess their own learning progress. Teachers also reported that students use feedback based on self-assessment to promote and improve their learning. In addition, teachers reported that the assessment of students' learning outcomes is based upon predefined criteria/rubrics, and that the learning activities are mainly shaped based upon feedback from ongoing assessment processes. The teachers emphasized that students' understanding is assessed continuously during and in the end of the learning process. Teachers assert that students are given detailed written feedback on their work in addition to marking, and that when students perform a task they receive immediate feedback.

Teachers reported also that during the past year, students have been given the opportunity to experience a self-learning such as learning by doing or learning based on teaching by presenting a topic or problem to other students.

**Findings of the second research question concerning: The correlations between science teachers' beliefs and their practice of pedagogical components of meaningful learning**

To answer the second research question, a series of correlation tests were performed by calculating the Pearson's correlation coefficient. Table 18 presents means and standard deviations of the beliefs and practice dimensions of pedagogical components of meaningful learning (PCML). As well, the findings show the Pearson coefficients for the relationships between practice and beliefs dimensions of each component. Every item in the belief section was paralleled by an item in the practice section while both of these items examine the same content but they were formulated differently (Appendix D). In addition, the findings show the relationship between the entire belief dimension and the practice dimension of the whole components.

**Table 18:** Means, standard deviations and Pearson's correlation coefficients for the relationship between the dimensions of beliefs and practice of PCML

| **Pedagogical component** | **Beliefs** | | **Practice** | | **Person correlation** |
|---|---|---|---|---|---|
| | Mean | S.D | Mean | S.D | r |
| Relevance (R) | 3.24 | 0.34 | 2.75 | 0.51 | 0.234** |
| Knowledge construction (KC) | 3.05 | 0.34 | 2.92 | 0.55 | 0.094 |
| Critical thinking (CT) | 3.19 | 0.45 | 3.17 | 0.57 | 0.209** |
| Feedback (FB) | 3.12 | 0.38 | 2.98 | 0.58 | 0.268** |
| Learning by doing (LBD) | 3.46 | 0.40 | 3.24 | 0.77 | 0.186* |
| Learning based on teaching (LBT) | 2.98 | 0.47 | 2.95 | 0.81 | 0.164* |
| **General** | **3.18** | **0.28** | **2.97** | **0.47** | **0.335*** ** |

*p<0.05, **p<0.01, ***p<0.001

The findings presented in Table 18 above indicate significant positive correlations between the dimensions of beliefs and the practice of each PCML (except for the component of knowledge construction). The findings also indicate significant positive correlations between general beliefs and general practice of the whole PCML ($r = 0.335$, $p<0.001$). It means that as general beliefs of the whole PCML increase, the general practice dimension of these components increase.

It was found that there is a significant positive correlation between the beliefs toward *relevance* component and the practice of the *relevance* component (r = 0.234, p <0.01). It means that as beliefs of *relevance* increase, the practice of this component also increases. There was also a significant positive correlation between the beliefs towards *critical thinking* component and the practice of *critical thinking* (r = 0.209, p <0.05), this means that the higher the beliefs towards *critical thinking* component the higher the practice of the *critical thinking* component will be. We can also see that there is a significant positive correlation between the beliefs towards *feedback* component and the practice of *feedback* (r=0.268, p <0.01), which means that as the beliefs towards *feedback* increase the practice of *feedback* component increases. There was also a significant positive correlation between the beliefs towards *learning by doing* component and the practice of *learning by doing* (r = 0.186, p <0.05), which means that as the beliefs towards *learning by doing* increase, the practice of *learning by doing* component increases. In addition, there was a significant positive correlation between the beliefs towards *learning based on teaching* component and the practice of *learning based on teaching* component (r = 0.164, p <0.05), which means that as the beliefs towards *learning based on teaching* increase, the practice of *learning based on teaching* component increases.

**Summary.** Based on these findings, it can be concluded that there are strong and moderate correlations between the beliefs and the practice of the PCML, as well as a strong positive correlation between the general beliefs and the general practices of PCML. In other words, as teachers hold positive beliefs and attitudes toward meaningful learning, they tend more to implement its various components.

**Findings of the third research question concerning: The correlations between specific background variables of science teachers and their practice of pedagogical components of meaningful learning**

To answer the third research question, the correlations between personal and professional background variables of science teachers such as gender, educational qualification, years of teaching experience and type of school and their practice of pedagogical components of meaningful learning (PCML) were examined. The correlations between the type of school, gender and educational qualification of the participants and their practice of PCML were determined using t-test for two independent variables. However, the correlations between years of teaching experience of the participants and the practice of the PCML were determined using the F-test. The findings are presented in the following tables.

**Table 19**: F-test and t-test values of general practice of the PCML for differences attributed to background variables

| Background Variable | Coefficient | General practice |
|---|---|---|
| Gender | t | -1.924 |
| Type of school | t | 1.736 |
| Educational qualification | t | -0.700 |
| Years of teaching experience | F | 1.024 |

The findings presented in Table 19 show F-test and t-test values of teachers' practice of the whole PCML for differences attributed to the various participants' background variables. The findings presented in the table above indicate that there were no statically significant differences between the means of teachers' practice of the whole components of meaningful learning attributed to their gender, years of teaching experience, type of school and educational qualification.

**Table 20**: Means and standard deviations of teachers' practice of PCML and t-test values for difference between them attributed to **gender**

| | | | Pedagogical components of meaningful learning | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Background Variable | Categories | | R | KC | CT | FB | LBD | LBT | **General** |
| Gender | Male | N | 43 | 43 | 43 | 43 | 43 | 43 | **43** |
| | | Mean | 2.65 | 2.77 | 3.05 | 2.89 | 3.12 | 2.72 | **2.86** |
| | | SD | 0.53 | 0.55 | 0.58 | 0.63 | 0.76 | 0.8 | **0.49** |
| | Female | N | 112 | 112 | 112 | 112 | 112 | 112 | **112** |
| | | Mean | 2.79 | 2.97 | 3.22 | 3.01 | 3.29 | 3.04 | **3.02** |
| | | SD | 0.5 | 0.54 | 0.56 | 0.57 | 0.76 | 0.8 | **0.46** |
| | t | | -1.520 | -2.050* | -1.717 | -1.189 | -1.236 | -2.187* | **-1.924** |

The findings presented in Table 20 show the teachers' responses (means and standard deviations) to the practice section items in the questionnaire regarding the PCML and t-test values for the difference between them attributed to gender. The findings indicate that there were no statically significant differences between the means of the teachers' practice of the *relevance, critical thinking, feedback* and *learning by doing* components of meaningful learning attributed to their gender. However, the findings indicate that there were statically significant differences between the means of the teachers' practice of *knowledge construction* component attributed to their gender ($t = -2.050$, $p < 0.05$) in favor of female teachers compared to male teachers. The findings also indicate a statically significant differences between the means of the teachers' practice of the *learning based on teaching* component attributed to their gender ($t = -2.187$, $p < 0.05$) in favor of female teachers compared to male teachers. consequently, females perceived their implementation of *learning based on teaching* and *knowledge construction* to be significantly higher than that of male teachers.

**Table 21**: Means and standard deviations of teachers' practice of PCML and t-test values for difference between them attributed to **type of school**

| | | | **Pedagogical components of meaningful learning** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Background variable | Categories | | R | KC | CT | FB | LBD | LBT | **General** |
| School type | State | N | 109 | 109 | 109 | 109 | 109 | 109 | **109** |
| | | Mean | 2.80 | 2.95 | 3.19 | 3.05 | 3.27 | 3.02 | **3.02** |
| | | SD | 0.53 | 0.56 | 0.59 | 0.56 | 0.77 | 0.78 | **0.49** |
| | Private | N | 46 | 46 | 46 | 46 | 46 | 46 | **46** |
| | | Mean | 2.62 | 2.85 | 3.13 | 2.81 | 3.17 | 2.78 | **2.87** |
| | | SD | 0.42 | 0.53 | 0.51 | 0.60 | 0.77 | 0.87 | **0.41** |
| | t | | 2.084* | 0.955 | 0.589 | 2.293* | 0.684 | 1.660 | **1.736** |

The findings presented in Table 21 show the teachers' responses (means and standard deviations) to the practice section items in the questionnaire regarding the PCML and t-test values for the differences between them attributed to type of school. The findings indicate that there were no statically significant differences between the means of the teachers' practice of the *knowledge construction, critical thinking,* *learning by doing* and *learning based on teaching* components attributed to the type of school. However, the findings indicate that there were statically significant differences between the means of the teachers' practice of *relevance* component attributed to school type (t = 2.084, p <0.05) in favor of teachers in state schools compared to teachers in private schools. In addition, a statistically significant difference was found between the means of the teachers' practice of the *feedback* component (t = 2.293, p <0.05) in favor of teachers in state schools compared to private schools. consequently, science teachers in state schools perceived their implementation of *relevance* and *feedback* to be significantly higher than that of science teachers in private schools.

**Table 22**: Means and standard deviations of teachers' practice of PCML and t-test values for difference between them attributed to **educational qualification**

| | | | **Pedagogical components of meaningful learning** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Background variable | Categories | | R | KC | CT | FB | LBD | LBT | **General** |
| Educational qualification | B.A,/B.Ed. | N | 73 | 73 | 73 | 73 | 73 | 73 | **73** |
| | | Mean | 2.72 | 2.9 | 3.12 | 2.98 | 3.14 | 2.92 | **2.94** |
| | | SD | 0.52 | 0.55 | 0.59 | 0.57 | 0.79 | 0.74 | **0.49** |
| | M.A./M.Ed. And up | N | 82 | 82 | 82 | 82 | 82 | 82 | **82** |
| | | Mean | 2.78 | 2.94 | 3.22 | 2.97 | 3.33 | 2.98 | **3.00** |
| | | SD | 0.50 | 0.56 | 0.54 | 0.60 | 0.74 | 0.87 | **0.47** |
| | t | | -0.721 | -0.456 | -1.077 | 0.148 | -1.569 | -0.441 | **-0.70** |

The findings presented in Table 22 show the teachers' responses (means and standard deviations) to the practice section items in the questionnaire regarding the PCML and t-test values for the differences between them attributed to the educational qualification. The findings indicate that there were no statically significant differences between the means of the teachers' practice of each component attributed to their educational qualification.

**Table 23**: Means and standard deviations of teachers' practice of PCML and F-test values for the difference between them attributed to their **years of teaching experience**

| | | | **Pedagogical components of meaningful learning** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Background variable | Categories | | R | KC | CT | FB | LBD | LBT | **General** |
| Years of teaching experience | 1-5 years | N | 7 | 7 | 7 | 7 | 7 | 7 | **7** |
| | | Mean | 3.12 | 3.00 | 3.23 | 3.10 | 3.43 | 3.14 | **3.14** |
| | | SD | 0.59 | 0.53 | 0.67 | 0.80 | 0.79 | 1.07 | **0.62** |
| | 6-10 years | N | 29 | 29 | 29 | 29 | 29 | 29 | **29** |
| | | Mean | 2.71 | 2.99 | 3.37 | 3.04 | 3.31 | 3.10 | **3.05** |
| | | SD | 0.51 | 0.54 | 0.52 | 0.49 | 0.71 | 0.86 | **0.43** |
| | 11-15 years | N | 30 | 30 | 30 | 29 | 30 | 30 | **30** |
| | | Mean | 2.83 | 3.04 | 3.20 | 3.04 | 3.20 | 2.77 | **3.01** |
| | | SD | 0.51 | 0.58 | 0.54 | 0.49 | 0.76 | 0.86 | **0.53** |
| | Over 15 years | N | 89 | 89 | 89 | 89 | 89 | 89 | **89** |
| | | Mean | 2.70 | 2.85 | 3.09 | 2.98 | 3.21 | 2.94 | **2.92** |
| | | SD | 0.49 | 0.55 | 0.57 | 0.53 | 0.79 | 0.76 | **0.46** |
| | F | | 1.842 | 1.177 | 1.853 | 0.300 | 0.282 | 0.987 | **1.024** |

The findings presented in Table 23 show the teachers' responses (means and standard deviations) to the practice section items in the questionnaire regarding the PCML and F-test (One-way analysis of variance) values for the differences between them attributed to their years of teaching experience. The findings indicate that there were no statically significant differences between the means of the teachers' practice of each component attributed to their years of teaching experience.

**Summary.** The findings indicate that there were no statically significant differences between the means of teachers' practice of the whole components of meaningful learning attributed to their gender, years of teaching experience, type of school and educational qualification.

Findings indicate that there were statically significant differences between the means of the teachers' practice of *knowledge construction* components and the *learning* *based on teaching* attributed to their gender in favor of female teachers compared to male teachers.

The findings indicate also that there were statically significant differences between the means of the teachers' practice of *relevance* and *feedback* components attributed to school type in favor of teachers in state schools compared to teachers in private schools.

The findings indicate that there were no statically significant differences between the means of the teachers' practice of each component attributed to their years of teaching experience and to their educational qualification.

## 2. The Qualitative Results of the Interview

This chapter provides a description of the qualitative findings of the interview. The interview aimed to identify conditions which may play a role in enhancing the implementation of meaningful learning (the fourth research question), as well, to identify obstacles that hinder this kind of learning in science teaching in middle schools from the science teachers' perspective (the fifth research question). The interview was formed from two main open-ended questions:

1. What conditions should be provided to enhance meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion?
2. What obstacles do science teachers face in implementing the meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion?

Table 24 provides personal and professional data of the interviewees followed by the themes (conditions and obstacles) emerged from the analysis of data collected in the interview.

**Table 24:** Participant's Personal and Professional Data

| | Gender | Age | Educational qualification | Years of teaching experience | School type |
|---|---|---|---|---|---|
| 1 | M | 50+ | B.Sc. | 15+ | **State** |
| 2 | F | 50+ | M.Ed. | 15+ | **State** |
| 3 | M | 40-49 | M.Sc. | 15+ | **State** |
| 4 | F | 40-49 | M.Ed. | 15+ | **State** |
| 5 | F | 40-49 | B.Ed. | 11-15 | **State** |
| 6 | F | 30-39 | B.Ed. | 11-15 | **State** |
| 7 | M | 50+ | M.Sc. | 15+ | **State** |
| 8 | F | 40-49 | M.Ed. | 15+ | **Private** |
| 9 | F | 40-49 | B.Sc. | 15+ | **Private** |
| 10 | F | 30-39 | B.Ed. | 15+ | **Private** |
| 11 | F | 50+ | M.Ed. | 15+ | **State** |
| 12 | M | 50+ | M.Sc. | 15+ | **Private** |
| 13 | F | 40-49 | M.Ed. | 11-15 | **Private** |
| 14 | F | 50+ | Ph.D. | 11-15 | **Private** |
| 15 | F | 30-39 | M.Ed. | 6-10 | **Private** |
| 16 | F | 30-39 | M.Ed. | 11-15 | **State** |
| 17 | F | 40-49 | M.Sc. | 15+ | **Private** |
| 18 | F | 50+ | M.Ed. | 15+ | **State** |
| 19 | F | 40-49 | M.Ed. | 15+ | **Private** |
| 20 | F | 50+ | M.Ed. | 15+ | **State** |

**Findings of the fourth research question concerning: The conditions should be provided to enhance meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion.**

To answer this question, three sub –questions were derived and aimed to focus on three kinds of conditions: pedagogical conditions, administrative conditions and conditions related to students. The questions were posed to each participant individually are:

1. In your opinion, what kind of pedagogical conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?

2. In your opinion, what kind of administrative conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?
3. In your opinion, what kind of conditions related to students could improve implementing of meaningful learning in science teaching in Arab middle schools?

The variety of attitudes, expressions and contents gathered in the interviews from each research question had been analyzed by the steps of analysis in qualitative research as presented in the methodology chapter.

**1. Pedagogical Conditions for Meaningful Learning.** In order to expose the pedagogical conditions that may promote meaningful learning according to science teachers' opinion, the teachers were asked the following question: "In your opinion, what kind of pedagogical conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?". Five themes (conditions) were emerged from the responses of participants. Frequencies and percentages for each theme listed were calculated, taking into account the order of the themes in descending order according to their percentages as shown in Table 25.

**Table 25**: Frequencies and percentages of themes in term of pedagogical conditions for enhancing meaningful learning

| Order | Themes associated with pedagogical conditions | N | Freq. | percentages |
|---|---|---|---|---|
| 1 | Application of digital tools | 20 | 13 | **65** |
| 2 | Exercising various teaching and assessment methods | 20 | 10 | **50** |
| 3 | Assessment for learning | 20 | 10 | **50** |
| 4 | Implementation of constructivist learning principles | 20 | 8 | **40** |
| 5 | Differentiated instruction | 20 | 6 | **30** |

Table 25 presents the five main themes (conditions) emerged from the interviews, the researcher will expand the discussion on each of the themes, using the quotes of the interviewees in order to increase the trustworthiness and clarity of the content.

**Theme 1 - Application of Digital Tools (N=13)**

The majority of interviewees emphasized the need of increasing the frequency of using the digital tools in science lessons. The tools mentioned in the interviews are: simulations, animations, videos, cellular telephones and computer experimentation. Participants considered these tools essential to illustrate abstract concepts, phenomena or even to assess students' learning.

The following exemplary quotes present the attempts of science teacher to engage students in digital technology. One teacher referred to the digital tools as an assessment tool that can give immediate feedback about the learners' work: "*I suggest to use digital tasks accompanied by feedback to give opportunity to the student to assess his/her work"*. Another teacher asserted the need for expanding the use of digital learning by this statement: "*The work should be expanded on using computerized tasks and computerized experiments*". Another teacher expressed the importance of digital tools to foster deep understanding and make the learning more relevant to the students: "*Using digital tools will help students understand, internalize and make the material more relevant and meaningful to the student*". She added: "*Students have the experience and the desire to use technological facilities in everyday life such as tablets, computers, smartphones. This may motivate them to use these facilities in science teaching*". This statement indicates that we can use the students' knowledge and everyday experience of using technology in order to apply in science lessons. Another teacher described digital tools as illustrative tools: "*Using digital tools allowed to present, clarify, explain phenomena, processes or structures that cannot be done by any other method*". In summary, science teachers see that using digital tools in science lessons can boost motivation for learning and stimulate deep understanding of science.

**Theme 2 - Exercising Various Teaching and Assessment Methods (N=10)**

Half of the interviewees emphasized the need of exercising a wide range of teaching and assessment methods to promote meaningful learning. The methods mentioned included: laboratory experiments, learning by inquiry, building models for illustration, learning through games, project based learning, extracurricular learning, observations and sightseeing, visits of museums or industrial plants, and others. One teacher gave an example for using various methods and strategies to teach the periodic table topic: *"When I teach the periodic table and elements, students in the class build models of periodic table, classify elements cards based on their characteristics, they* *use problem solving and discussions, they present story about the periodic table and they collaborate in collecting information about elements to make presentations".* One teacher asserted on the importance of using various methods to construct knowledge and developing skills: *"Students should be given the opportunity to be exposed to different teaching methods such as computer, mobile, models, experiments, simulation and games for constructing knowledge and skills".* Another teacher gave an example for learning based technology to produce video about valuable issue such as raising the awareness of environmental protection: *"In one learning activity students made picnic in the surrounding area, they created a video about the need of preserving the cleanliness of the environment, in this activity students used digital sources based on their knowledge and skills to create the video".* In the assessment context, one teacher gave an example of using various methods and tools to assess students' learning and understanding: "*To assess students' understanding of the learning material several methods could be used, including: asking questions during the lesson, making frequent tests (continuous assessment), summarizing what the student understands in his words, using portfolio and use laboratory reports as an alternative tool for assessment".* In summary, science teachers see importance of using various teaching and assessment methods which allow differentiated instruction that make learning more relevant and meaningful for students.

**Theme 3- Assessment for Learning (N=10)**

Half of the interviewees emphasized the importance of using assessment to improve learning and teaching processes as expressed as follow: conducting frequent tests to monitor students' progress exemplified by the quote: "*The frequency of the assessment should be increased. By performing many frequent mappings, we can receive feedback on teachers' teaching and students' understanding*". Science teachers believed that it is important to assess students' understanding by questioning and discussion, clarifying the points that were not understood during the course of the lesson: *" In order to assess students' understanding of the lesson, questions should be asked before, during and at the end of the lesson".* Some teachers asserted to engage students in self-assessment as quoted in this statement: *"Students are asked to write what they learn from the learning activity, draw, ask question, make feedback and discussion about what they learned".* In summary, science teachers believe that getting feedback from ongoing assessment and self-assessment is essential to gain better outcomes in science.

**Theme 4 – Implementation of Constructivist Learning Principles (N=8)**

Some teachers in the interview suggested constructivist learning principles to generate meaningful learning in science teaching. The following quotes exemplify these principles.

**The knowledge Construction Principle.** Some teachers expressed the need for knowledge construction by the following quotes: "*Student should be active and able to construct his knowledge by himself through inquiry within teachers' guiding*", "*Students should be given the opportunity for self-learning a particular topic and present it to other students in the classroom*", "*The student should be guided to relate the material learned in the previous lesson to the material will be taught in the new lesson*", "*The student should be given the opportunity to think, inquire, discover and reach knowledge by himself. In this case he teacher plays only the role of the guide, observer and scaffolder for the student's learning process".* The teachers emphasized the importance of development of higher order thinking skills: *"Students should be given opportunities to develop higher skills such as linking information or ideas, building arguments, drawing conclusions, asking questions, analyzing data and constructing hypotheses"*.

**The Active Principle.** Teachers in their teaching focused on the active role that students should take in the lesson mentally, physically, socially and emotionally. The active principle exposed in the interviews is described in the following examples: "*The teacher must give the student an opportunity to take an active role in the learning process as participating in projects and inquiries*"; another teacher stated that: "*Student should be encouraged to think independently and to be given an opportunity to express his opinion and to be involved in learning so that learning will also be meaningful to the student*". Some teachers expressed the need for active learning by these examples: *"Students should take an active role in their participation in the experiment. They should take responsibility for their work".* One teacher asserts that: *"The learning activity should be student's centered in which he takes an active role in that activity".*

**The Cooperative Principle.** Cooperative activities were also described by these statements: "*In learning activities students should divided to small groups", "When students participated in the learning activity they should be given the* *opportunity to cooperate with each other and respect each other*". Some teachers gave actual examples on cooperative learning in their lessons: "*In small groups I gave the opportunity to make discussion about a problem that I presented, each student attempted to convince other students why his opinion is correct and try to give them explanations. Students learn from each other, listen to each other and develop leadership*", *"Students would work in small groups, every group read a text, they summarize the information from the text and introduced to the other groups, in this activity students were active*", "*Students divided into groups, every group played a role. Some of them played as lawyer others played as judge. Every student took responsibility of his role".*

**The Relevance Principle.** Some respondents suggested that teachers have to try to make the content learned valuable and relevant to the student. The examples that teachers proposed to make learning science relevant: "*Students should be empowered with the issue of values, especially social values, such as respect and show tolerance to each other*"; "*To explain to the students why they learn a particular topic, for example, how it relates to other topics in daily life and giving examples from the students' daily life*"; "*Learning should be based on the student's personal interest*"; "*Let students choose and decide what material will be learned from the curriculum so that the topics they learn will be more relevant and interesting for them*"; *"When planning lesson, it is important to make the learning material relevant to their real world and to make it interesting".*

According to the literature, Meaningful learning is the underlying theme of constructivism. Thus, these constructivist principles can be considered essential pedagogical conditions for promoting meaningful learning.

**Theme 5- Differentiated Instruction (N=6)**

Differentiated teaching is an instruction adapted to the student's individual characteristics and abilities and is one of the conditions reported by teachers as a condition for promoting the implementation of meaningful learning in science. Differentiated teaching was expressed by suggestions to use different learning styles, dealing with difference in learning abilities and needs: "*The teacher should adapt the appropriate learning styles to the students according to their preferences*"; "*The teacher should divide the contents into sub-topics., each topic should be taught in a* *different learning style according to the learning style appropriate for each student*", "*Taking into considerations the differences in student learning levels, thus, each child can progress according to his level* ", "*There is a need for differentiated teaching and for addressing the differences between students and the use of appropriate teaching methods, which can encourage learners and their progress*", "*The student should be given the opportunity to choose the appropriate assessment method*", "*The teacher must adapt the teaching to the different needs of the students, which may help the student become more involved in the learning process*", "*It is necessary to relate to the different characteristics and capabilities of the students and to fit for them the appropriate frameworks*". One teacher exemplified the use of differentiated instruction as follow: "*In science lessons I attempt to adapt teaching methods and strategies according to the students' individual differences in the abilities, learning goals and learning styles*".

**2. Administrative Conditions of Meaningful Learning.** In order to expose the administrative conditions that promote meaningful learning, the teachers were asked the following question: "In your opinion, what kind of administrative conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?". Six themes (conditions) were emerged from the responses of participants. Frequencies and percentages for each theme listed were calculated, taking into account the order of the ideas in a descending order according to their percentages as shown in table 26.

**Table 26**: Frequencies and percentages of the themes in term of administrative conditions for enhancing meaningful learning

| Order | The themes associated with administrative conditions for enhancing meaningful learning from the perspective of the participants | N | Freq. | Percentages (%) |
|---|---|---|---|---|
| 1 | Resources | 20 | 17 | **85** |
| 2 | Principal support | 20 | 13 | **65** |
| 3 | Professional development | 20 | 12 | **60** |
| 4 | Curriculum | 20 | 11 | **55** |
| 5 | Autonomy and flexibility | 20 | 10 | **50** |
| 6 | Professional team collaboration | 20 | 4 | **20** |

Table 26 shows the six main themes emerged from the interview, the researcher will expand discussion on each of the themes as follow:

**Theme 1-Resources (N=17)**

The availability of physical/material and human resources were the main administrative condition that teachers have pointed out in order to establish meaningful learning. The various resources pointed out by the interviewees are:

**A. Physical/Material Resources:**

1. Teaching hours: Teachers suggested to add more hours for teaching science.
2. Laboratory room: Teachers suggested that an innovative and designed laboratory is required, equipped with all materials and facilities necessary to carry out the experiments offered in the curriculum.
3. Computer room: setting up a computer room with internet infrastructure including technological equipment such as a projector, tablets, microphones, earphones, tape recorders, smart board and others.
4. Learning centers/spaces: Setting up learning centers with decorative and aesthetic spaces which contains models, shapes, colors and other facilities for illustration.
5. Training and guidance :teachers suggested to add more hours of training and guidance for science teachers that provide innovative instructional methods and strategies which enable meaningful learning and encourage teachers to increase their motivation to develop and lead change.
6. Budgeting extra-curricular activities: budgeting for extracurricular learning such as visiting factories, science-centers and museums.

**B. Human Resources:**

1. Laboratory technician: An experienced and knowledgeable laboratory technician as an assistant for the teacher in the laboratory during the experiments in which students are involved.
2. Computer technician: As an assistant for the teacher in the computer room during an online activity.

**Theme 2- Principal Support (N=13)**

According to the science teachers' response, meaningful learning cannot occur without the support of the principal. The support of the principal is a necessary condition for the advancement of teaching and learning processes. The principal's support enables the teacher to mobilize his powers in order to lead to fruitful and successful pedagogical processes. Most teachers emphasized the importance of the support of the principal as implied by the following quotes: "*The principal should support the decisions of the teacher to lead a change*", "*The principal should support the teacher in any project that will give the student an opportunity for self-learning*", "*The principal should give full authority, support and appreciation to teachers*", "*The principal should have readiness to develop the learning environment, and various opportunities that contribute to the development of 21st century skills*"; "*The principal should give pedagogical flexibility and decision-making, and enable freedom of choice*", "*The principal is ready to lead a change in science teaching*".

**Theme 3- Professional Development (N=12)**

Interviewees suggested to more enrollment in professional development to promote meaningful learning. Most teachers indicated of the need to expand science teachers' knowledge how to achieve meaningful learning and to develop the skills adapted for the 21st century. The importance of the professional development was expressed in the following statements: "*There is a need for professional development and practical training for science teachers which suggest to them new approaches and strategies for implementation meaningful learning in the science lessons*", "*Teachers must/should undergo professional development in the field of meaningful learning that aims to give guidance to teachers how to use pedagogical tools to help them to implement teaching practices that promote meaningful learning*", "*A teacher needs to learn an innovative teaching methods and practices such as learning through games, learning through inquiry, using digital pedagogy that make learning more relevant and enjoyable to the student*", "*The Ministry of education should monitor the extent of implementation what is learned in the professional development in schools in the field of meaningful learning*".

**Theme 4- Curriculum (N=11)**

Almost half of the teachers referred to the importance of adapting the curriculum and updating it to requirements that allow meaningful learning. The teachers expressed that by the following quotes: "*Reducing the learning materials in the curriculum in order to conduct more experiments and inquiry or project based learning because these methods require too much time*", "*Selecting interesting, attractive and relevant contents from the real world of the student* ", "*The Ministry of education should ensure that the materials in the curriculum are suited to the age of the student*", "*The Ministry of education should review and update curriculum contents, values and skills to be adapted to the 21st century*".

**Theme 5-Autonomy and Flexibility (N=10)**

Flexibility and autonomy in the teacher role is one of the conditions that half of the interviewees indicated in order to enhance meaningful learning. This flexibility and autonomy allow to adapt learning to the local conditions of the school and to the characteristics of the various student groups. The interviewees expressed the need for autonomy and flexibility in the role of the teacher as described in the following statements: "*The teacher should be autonomous in choosing the appropriate teaching methods such as games, experiments and computerized tasks*"; "*Providing freedom to the teachers to select various teaching tools relevant to the lesson*"; "*Giving flexibility to the teacher to choose what topics or contents students should learn, and invite the conditions to enable students self-learning as much as possible*"; "*The teacher should not be obligated only to the curriculum or books, there is a need for creativity and working outside the box*", "*There is a need for flexibility in determining the assessment methods and tools adapted to the students*".

**Theme 6 - Professional Team Collaboration (N=4)**

Another condition for promoting meaningful learning offered by the teachers is cooperation between the teachers of the professional staff. The interviewees pointed out that: "*Teachers have to increase the cooperation and the dialogue between them in the professional team*"; "*A requirement to develop a learning community to make observations and sharing ideas and that lead to encouragement and support among the staff*"; "*Improving the quality of teaching through the preparation of shared lesson plans based on the principles of meaningful learning*"; "*Collaboration in dealing with* *common issues, for example dealing with abstract topics that students have some difficulty in understanding*"; "*Between the professional staff members should be a pleasant atmosphere, a respectful relation and mutual trust*".

**3. Conditions of Meaningful Learning Related to Students**

In order to expose conditions of meaningful learning related to the students, the teachers were asked the following question: "In your opinion, what kind of conditions related to students could improve implementing of meaningful learning in science teaching in Arab middle schools?".

A variety of attitudes, expressions and contents that refer to conditions of meaningful learning related to students was emerged from the interviews. It was also noted that based on teachers' answers some themes were belonging to other kinds of conditions such as pedagogical and administrative conditions which have been categorized finally in these two kinds of conditions.

The interviewees suggested conditions related to students to promote meaningful learning as described in the following quotes: "*Students should have the motivation and the desire to learn science, the higher the motivation to learn, the more fruitful results will gained in the learning process*"; "*An open mind and responsible student who is motivated and prepared for learning*"; "*The student have to be aware of the importance of the subject of sciences to real life and future life*"; "*Students need background and previous knowledge in addition to basic skills such as reading and writing ability, computer use, self-learning ability, knowledge of scientific inquiry principles, knowledge of the use of the internet, curiosity and tendency to explore*"; "*The students ready to be involved in the learning process*"; "*Students should have cognitive abilities*"; "*Normal personal background such as socioeconomic background, social and family status*"; "*Discipline and internal motivation among students*".

**4. Teacher-Student Relationship**

The interviews also revealed another condition in order to enhance meaningful learning and it was related to the teacher-student relationship. This condition was emerged from the overall contents of opinion that teachers were express in the answers of the all three sub-questions and it was set as additional condition. The interviewees pointed out that: "*A relationship of caring between teacher and student is an important condition for bringing students closer to the teacher and thereby makes the student* *loves science*", "*The teacher should accept the student as he is and give him the feeling that he is acceptable*"; "*Teacher must be supportive, encouraging and loving for students*", "*Positive communication between teacher and student in the classroom is an important factor that promotes implementation for meaningful learning*". As well, the teachers emphasized this condition by the following expressions: "*The relationship between the student and the teacher is very important, and contributes to the integration of the student and foster the learning process, "Good relationship between the teacher and the student contributes to students' motivation to learn the subject and to achieve learning goals", "The teacher must be close to the student's world and know his social and personal status and his interests", "The teacher have to listen to the students, encourage them, give them positive and constructive reflection", "Giving moral reinforcements, understand him and know his needs".*

**Summary.** This question focused on identifying conditions that may enhance meaningful learning in science teaching according to science teachers' opinion in middle schools. These conditions were classified into three kinds before the interview conducting: pedagogical conditions, administrative conditions and conditions related to students. Through analyzing the contents of the pedagogical condition, five themes were emerged from the responses of participants. These themes ordered by descending order according to their percentages of responses as following: application of digital tools; exercising various teaching and assessment methods, assessment for learning, implementation of constructivist learning principles and differentiated instruction. Regarding the administrative conditions, six themes were identified. These themes ordered by descending order according to their percentages of responses as following: resources; principal support, professional development, curriculum, autonomy and flexibility of the teacher role and professional team collaboration. The conditions associated with students include: students' motivation to learn, having open mind and responsibility, students' awareness of the importance of sciences to real and future life, having previous knowledge of the content will be learned and various basic skills and good personal and socioeconomic background. These conditions suggested as being the crucial conditions for promoting meaningful learning. The interviews also revealed another condition in order to enhance meaningful learning, it related to the teacher-student relationship. This condition was emerged from the overall content of opinion that teachers expressed through their answers of the all three sub-questions.

Consequently, teacher-student relationship is considered by teachers an important condition for bringing students closer to the teacher and thereby makes the student love science and boosts his motivation to learn science.

**Findings of the fifth research question concerning: The obstacles that science teachers face when they implement meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion**.

In order to expose the obstacles that hinder the enhancing of the implementation of meaningful learning, the teachers were asked the following question: "In your opinion, what obstacles do science teachers face in implementing the meaningful learning in science teaching in Arab middle schools?".

To answer this question, the contents of the ideas in the responses of participants has been analyzed by the steps of analysis in qualitative research. Frequencies and percentages for each theme listed under the question were calculated, taking into account the order of the ideas in descending order according to their percentages as shown in Table 27.

**Table 27**: Frequencies and percentages of the themes in term of obstacles that hinder the meaningful learning implementation

| **Order** | **The themes associated with obstacles that hinder meaningful learning implementation from the perspective of the participants** | **N** | **Freq.** | **Percentages (%)** |
|---|---|---|---|---|
| 1 | Educational workload | 20 | 11 | **55** |
| 2 | Teachers' beliefs | 20 | 8 | **40** |
| 3 | Lack of professional qualification | 20 | 6 | **30** |
| 4 | High class size | 20 | 6 | **30** |
| 5 | Personal students' characteristics | 20 | 4 | **20** |

Table 27 presents four main themes emerged from the interviews, the researcher will expand on each of the themes, using the quotes of the interviewees, in order to increase the trustworthiness and clarity of the content.

**Theme 1- Workload (N=11)**

According to the interviewees' opinion, workload does not allow instruction for meaningful because teachers are required to fulfill others tasks which take time and efforts. Examples of teachers' statements that expressed the workload and its influential role: "*The workload of tasks imposed to teachers and students prevents instruction for deep learning of learning material*", "*The educational system requires the teacher to teach too much material before the external test of the ministry of education, named Mitzav*", "*The workload on teachers to teach many subjects, makes learning more superficial and not deep, this will not give the student a chance the to think and learn by himself*", "*The workload of teaching and preparing for external test such as Mitzav limits force teachers to use instructional practices that will not lead to meaningful learning, and the focus is on covering the material to the Mitzav test*", "*The workload, such as mapping tests, preparing work plans and filling out reports is may hinder adopting strategies for promoting meaningful learning because it takes time to do these tasks*", "*Teachers may make insufficient attention to develop students' thinking skills because teachers have to cover too much material, hence they teach for finishing the material and not teaching for understanding*".

**Theme 2-Teachers' Beliefs (N=8)**

Some teachers emphasized the effect of science teachers' beliefs on science teaching which may play as an obstacle for implementing meaningful learning. Examples of teachers' statements that expressed the effect of teachers' beliefs: "*Teachers may does not have the thinking or the perspective to lead change in teaching for meaningful learning*", "*Teacher's lack of readiness for change and development in his field*", "*Some teachers participate in the professional development in science mainly for expanding their knowledge in the field they teach and not to for implementation in the class*", "*Teachers adopt the perspective of transmitting knowledge rather than constructing it by students himself*".

**Theme 3 –Lack of Professional Qualification (N=6)**

Most teachers claim that without professional qualification of teaching for meaningful learning, they will not have the appropriate tools to implement meaningful learning. The interviewees emphasized the lack of teacher professional training for meaningful learning as a hindrance to its occurrence. Examples of teachers' statements that expressed lack of professional qualification: "*Teachers do not have the tools and skills to lead to meaningful learning process, teachers are with limited abilities and minimal knowledge insufficient to lead to meaningful learning*", "*Teachers may find difficulty in implementing innovative teaching strategies and methods that require qualification*", "*Lack of knowledge to use teaching that encourages higher-order thinking skills development such as application, analysis and evaluation*"; "*Difficulty in adapting the learned material to different students in the same class, i.e. dealing with heterogeneity in class*".

**Theme 4-High Class Size (N=6)**

Some of the interviewees noted an additional condition that could be a hindrance the implementation of meaningful learning, the high number of students in the class. The interviewees reported this as it seen in the following quotes: "*Some schools have 40 students in the classroom, which makes it difficult for the teacher to reach every student, in this situation some of the students will be deprived*", *"The number of students in the classroom should be reduced or divided into small groups or an assistant should be attached to each teacher for helping to reach every student*"; "*The number of students in the classroom limits the teacher to use teaching / assessment methods that promote meaningful learning such as learning through inquiry, portfolio, laboratory experimentation, etc.*", "*The number of students must be divided into two groups to enable greater use of teaching practices that promote meaningful learning".*

**Theme 5- Students' Personal Characteristics (N=4)**

Some of the interviewees pointed out that there are characteristics related to the student himself which play as obstacles that limit or inhibit meaningful learning. Some teachers referred to the effects of the disciplinary problems on implementing meaningful learning: "*Difficult student's population, I mean students with disciplinary problems, a class in which there are no disciplined students, there cannot be a process of effective learning, discipline is a prerequisite for meaningful learning*". Some other participants referred to characteristics related to the student's abilities, such as "*The limited cognitive ability of students is a hindrance to the implementation of meaningful learning*". Other teachers referred to the effect of socioeconomic status, "*Low socioeconomic status is an obstacle that hiders learning in general*", others assert on the necessity of parents' support, "*Lack of parents' support such parents who do not collaborate or follow the progress of their son will hinder the implementation of meaningful learning*".

**Summary.** This question aimed to expose the obstacles that may hinder the enhancing of implementing meaningful learning in science teaching according to science teachers opinion in middle schools. Through analyzing the contents of the teacher's opinion, five themes (obstacles) were emerged from the responses of participants. These themes ordered by descending order according to their percentages of responses as following: educational workload, teachers' beliefs, lack of professional qualification; high class size and students' personal characteristics.

# CHAPTER VI

# DISCUSSOIN AND CONCULUSIONS

In this chapter, the researcher provides discussion based on the findings of the questionnaire and the interviews, presents the limitations of the study and make suggestions for future research in this area, draws conclusions and set recommendations of the whole study.

## 1. Discussion

In this section, the researcher discusses the five research questions in terms of the results of the data analysis. The five questions refer to: 1. Teachers' beliefs and practice of pedagogical components of meaningful learning (PCML), 2. Correlations between practice and beliefs of PCML, 3. Correlations between practice the PCML and teachers' background variables such as gender, type of school, educational qualification and years of teaching experience, 4. Conditions for enhancing meaningful learning, 5. Obstacles hindering meaningful learning.

### Research question 1: Teachers' Beliefs and Practice of PCML

**Teachers' Beliefs of PCML.** Based on the findings of the beliefs section of the questionnaire, it can be concluded that science teachers in middle schools hold high positive beliefs towards pedagogical components (dimensions) of meaningful learning with a general mean value of 3.18. This finding shows that science teachers believe in teaching that promotes meaningful learning. This proves that these teachers are aware of the importance of this type of learning and this may stem from the knowledge that teachers have acquired from professional development or any other documents regarding meaningful learning which were published by the ministry of education. A research evidence has shown that teachers' beliefs about teaching and the learning of science influence their teaching practice (Fang, 1996; Laplante, 1997). Therefore, it seems apparent that teachers' beliefs towards pedagogical components for facilitating meaningful learning have important role in influencing positively the effective implementation of these components in the classroom. This issue will be discussed in the second research question.

*Relevance* as the constitutive component of meaningful learning, has mean value of 3.24. This indicates that science teachers believe that making learning activity relevant to students is important to make their learning meaningful. *Relevance* is considered prerequisite to meaningful learning (Yager, 1996; Ausubel, 1978), science teachers in this study expressed positive beliefs for enhancing meaningful learning by referring to this component. In this regard, Kember and McNaught (2007) support this finding in their analysis of interviews which show the importance of *relevance* of the subject to the learner as one of ten characteristics of effective teaching.

Teachers' responses indicate to high mean value of most items that construct this component. For instance, the item no. 5 in table 4 states that "Student learns better when the learning activity focused on students' interest is close to his/her life" received the highest mean value of 3.68. This mean that the majority of teachers (99%) seeing an importance of connecting the students' learning to their personal interests and their life. Students mostly pay attention to the learning activity when the teacher presents the topic in a way that capture student interest, thus, making learning interesting for learner is a main key to motivate them to learn and discover. Supporting this idea, Steven (2014), who noted that students are more likely to pay attention and be excited about learning the content when they view the class as relevant to themselves and connected to their interests. These findings are supported by another study show that students believe that science should be taught in a manner that capture their interest (Hofstein, et al., 2011).

However, the positive form of item no 6 in table 4 that states "Topics the students learn in the classroom are necessarily have to be related to the students' personal goals or future areas of work they are interested in" received the lowest mean value of 2.25. This mean that the majority of teachers (63%) do not see that personal goals of the students or future areas of work can play a role to facilitate their learning. This finding may be attributed to the point of view of the teachers that students vary in personal goals or future areas of work and it may have attributed also to that in adulthood students change their thinking about things frequently including defining their personal goals and future career. This finding is inconsistent with Briggs (2014) which noted that students' future goals are not just help students to realize the content is interesting but also why it is worth knowing.

Regarding the consecutive components of meaningful learning, the *knowledge Construction* component received relatively high mean value of 3.05. This finding indicates that science teachers expressed positive beliefs towards this component.

Teachers believe that students should construct their knowledge by themselves. In this way the knowledge they construct will be more relevant for them. This result can be supported by the findings in the fourth research question (in the interview) in this study which aims to identify conditions for enhancing meaningful learning. One condition suggested by teachers in the interview is the active role that should students take in constructing their knowledge. Forbes et al. (2001), states that constructing knowledge is important for students' learning because it ensures students are experiencing meaningful learning. In this regard, Hammond (1992) asserts that people learn best when they make connections or links between what they already know and what they learn, when they can draw on their experience and make greater meaning of them, when they see how ideas relate to one another, and when they can use what they are learning in concrete ways (Hammond, 1992).

The item no. 11 in table 5 states that "Students learn best by finding solutions to problems themselves" received the highest mean value of 3.49. This mean that the majority of teachers (95%) believe that students can improve their learning if they have the opportunity to activate their cognitive skills to use the knowledge they acquired for problem solving. In this way teachers also examine if the student understood deeply the learned material or not. Supporting this idea, Michael & Modell (2003), who points out that the ability to generate multiple representations or models of knowledge being learned and connecting them to prior knowledge, is both a sign of deep understanding and meaningful learning as it enables students solving problems in a different situation using this knowledge. However, item no. 10 (reserved item) in table 5, states "Students can succeed in learning a content whether if they use high-order thinking processes or not". The positive formulation of this item received the lowest mean value of 2.31. In other words, the majority of teachers (62%) believe that they can succeed in their learning even without using high-order thinking processes which are important to knowledge construction. This finding may be attributed to that some teachers believe that knowledge can be achieved without investing efforts or thinking, it can be transmitted from various sources such as teachers, books, internet etc… This finding is inconsistent with Zhu (2006) who points out that for knowledge construction students have to use high-order thinking processes such as seeking, interpreting, analyzing and summarizing information, critiquing and reasoning through various options: arguments, justifications and making decisions (Zhu, 2006).

The *critical thinking* component also received high mean value of 3.19. Thinking is an essential component for meaningful learning occurrence. According to Perkins (1998), knowledge should be acquired in active way which develops thinking that turns passive knowledge which is not connected into active and connected knowledge which is the basis for meaningful learning (Perkins, 1998). The teachers expressed their support and positive attitudes towards the importance of critical thinking as a component for enhancing meaningful learning. For instance, teachers perceived their students as active partner in thinking such as analyzing, judging, taking position, reasoning giving different point of view, etc… This is crucial for making learning meaningful for them. Furthermore, the Partnership for 21st Century Skills identifies critical thinking as one of several learning and innovation skills necessary to prepare students for post-secondary education and the workforce (Century Curriculum and Instruction, 2007).

The item no. 18 in table 6 states that "Students are supposed to provide explanations and reasons why their point of view is the right one" received the highest mean value of 3.43. This mean that the majority of teachers (96%) believe that it is not sufficient only to give an answer or solution to any problem offered by the students, it is important also to explain why their answer is right according to their opinions. Supporting this finding, Halpern (1998) who states that students have to develop their reasoning ability (Halpern, 1998) and their interpreting and explaining ability (Facione, 1990).

Teachers expressed their support and positive attitudes towards the importance of *feedback*, its necessity and vitality in the students' learning process. This component received relatively high mean value of 3.12. The teachers believe that learning becomes more effective when students assess personally their learning progress, students will be more successful if feedback from self-assessment used to improve their learning performance. As well, the students understanding should be assessed not only at the end of the unit's teaching it should be an ongoing assessment, teachers should to provide written feedback on students' work in addition to marking and learning is more effective when the teacher provides immediate feedback to students during their work on a task. This may be attributed to that teachers see the continuous assessment and feedback received from this assessment are a crucial part of the teaching-learning process. In addition, it allows students to make reflection on their work and it can help them to be aware of their understanding or misunderstanding of the learning material and accordingly make adjustments. Supporting this finding, Sadler (1989) who maintains that feedback helps learners become aware of any gaps that exist between their desired goal and their current knowledge, understanding, or skill and guides them through actions necessary to improve their learning and obtain its goals. As well, this finding supported by Hattie's (2009) synthesis of meta-analyses related to learning, he found that feedback was one of the most powerful influences on achievement and learning.

The item no. 23 states "Assessing students' learning outcomes should be based on predefined criteria/rubrics" received a highest mean value of 3.48. This finding indicates that teachers believe that it is important to set criteria or to build rubrics when they come to assess their students. It may be attributed to that this will make it easier for teachers to make accurate and uniform assessment among all the students and hence it will allow fair comparison between them when they provide feedback on assessment results.

Supporting this finding, Barron and Hammond (2008), who state that when students' work assessed according to predefined criteria, often using tools, such as rubric or focus questions, will help them to monitor their understandings, rethink and reflect on their work.

The item no. 24 (reversed item) states "Feedback from ongoing assessment plays a problematic role in designing the learning activities" received in its positive form the lowest mean value of 2.33. This indicates that teachers believe, to some extent, in the difficulty of designing the learning activities based on feedback provided from ongoing assessment. One explanation to this finding may be attributed to that teachers think that performing ongoing assessment needs to invest more efforts and time. This finding is inconsistent with Hipkins et al. (2002) who points out that providing detailed and ongoing feedback is necessary for effective learning as students need information about their accomplishments in order to grow and progress.

Teachers also expressed positive support for the importance of *learning by doing* in the learning process of students. This component received mean value of 3.46. For instance, teachers believe that students will learn more effectively in l*earning by doing* comparing learning by listening to a teacher's lecture, *learning by doing* is a way that makes it easy for the student to learn the content and a student who learns by doing will understand the material learned faster. The finding may be attributed to that science is a subject based basically on empirical aspects. In other words, the knowledge we use today emerged from experimental work such as scientific inquiry and thus learning should be based on discovery and inquiry. Supporting this finding, Greenberg (2014) who notes the importance of physical activity to normal brain development and improved management skills, including the ability to solve complex problems, process information and activate memory, concentration and attention. The finding is also in line with Kangasvieri et al. (2011) who states that engaging in physical activities develops teamwork skills, self-direction, the ability to co-operate with different people and improves test results, in particular in tasks requiring executive functions and memory.

The item no. 28 "Learning a topic by doing leads to a better understanding of this topic" received a highest mean value of 3.77. This finding indicates that teachers believe that learning which involves experimenting, constructing models or products, making measurements, conducting inquiry, using project-based learning leads to better understanding of the material they learn. This may be explained by that teachers see 'doing' as a way to activate students mentally to seek, think, connect ideas and to connect them emotionally and physically to learning material. Supporting this finding, Jeff and Smith (2005), they suggest that enlarging experience is as much about the deepening of an understanding of our experiences as it is about building them up (Jeff and Smith, 2005). Although science teachers have positive attitudes towards *learning by doing*, they believe that *learning by doing* needs to invests more time and efforts when students come to learn a topic.

Regarding the *learning based on teaching* component, teachers expressed their beliefs to this component which received mean value of 2.98. For instance, teachers believe that a student who learns new content in order to teach it to his classmates will better understand this content and learns more effectively this content. Teachers beliefs regarding *learning based on teaching* may attributed that giving the student the opportunity to prepare a lesson to teach it to their classmate make him feel more responsible for his learning, he will learn more deeply and use the best strategies and instructional methods and styles that relevant and suitable for him. The finding is in line with Topping et al. (2015), they explain the benefits of peer tutoring (learning based on teaching) as it helping the students improve academically. According to Deer Wolf

(2001), allowing students to take the teaching role allow them to use their prior knowledge to promote meaningful and effective learning (Deer and Wolfe, 2001).

The item no. 33 "Student who learns new content by himself/herself in order to teach it to his/her classmates will better understand this content, compared to learning it by listening to a teacher's lecture" received the highest mean value of 3.3. This may be attributed to that teachers think that students in the class do not get individual treatment due the high number of students and it may also emerge from the thought that when students learn alone they are more focused and try to use learning strategies that more convenient for them.

**Teachers' Practice of PCML**. Based on the findings of the practice section of the questionnaire, it can be concluded that the readiness and the willingness of science teachers in middle schools to implement different pedagogical components of meaningful learning is in a level with a general mean value of 2.97. This value as it classified means that science teachers in middle schools implement *frequently* the pedagogical components of meaningful learning. This finding points to the importance and the attention that science teachers attach to meaningful learning and to the actual practice of its various pedagogical components in the science lessons. This result may be attributed to the fact that science teachers have the knowledge and the awareness of the importance of implementing these pedagogical components to increase the motivation and involvement of students in the learning process. Middle school science teachers are offered a number of courses each year in the field of meaningful learning or training in areas related to meaningful learning such as developing high order skills, assessment for learning, scientifical thinking and so on. This fact can explain why they declared high extent of implementation of the pedagogy of meaningful learning in their classes. In addition, as can be seen from the findings of the beliefs section above, it can be concluded that science teachers in middle schools believe in the pedagogical principles that enable meaningful learning. This finding supported by the literature review which show that beliefs may play significant influence on the implementation of school reforms (Yan, 2014).

The *relevance* component has mean value of 2.75. This value as it classified means that science teachers in middle schools implement *frequently* the component of *relevance*. This result can be attributed to the fact that teachers think that the *relevance* component is an important component for increasing students' internal motivation to learn. Relevance is one of the three principles of meaningful learning set by the Israeli Education Ministry (Israel, Ministry of Education, 2013). The teachers' responses indicate that they make the content under study relevant to the student by using different ways, such as linking the new knowledge to previous knowledge that the student has acquired in the past, linking the content or activity learned to the student's daily life, encouraging students to be more involved in constructing their own knowledge. This finding is in line with other finding in this study that related to the fourth research question which presents the relevance as a pedagogical condition for enhancing meaningful learning according to science teachers point of view. This may be connected to some cases in the class when teachers face questions asked by students such as: why should we learn this? Why it worth to know? How it links to our life or our future?

The item no. 4 "Teacher state explicitly why it is important to the students to learn a particular topic" received the highest mean value of 3.3. This value as it classified means that science teachers in middle schools implement *always* the activity described in this item. This result may have attributed to that schools should invite students to engage in learning that is considered valuable for them, students should be aware why they learn this topic and how it contributes to their life or future. Supporting this finding, Purkey (1992) who points out that teachers should help students to see the value of investing in the targeted practice of learning school subjects. This finding also supported by Mayer (2002b), who notes that students work hard when they value what they learn, in other words, when the topic they learn is worth to know or important to them. In line with this, Earl (2013), maintains that if students are going to take responsibility for their learning, they need to know what is the big idea or the purposes from learning the subject and how parts of this idea are related and adapted to each other (Earl, 2013).

The item no. 3 "Students are given the opportunity to decide what topics they are going to learn and which learning activities they will do" received the lowest mean value of 1.78. This value indicates that science teachers in middle schools implement *occasionally* the activity described in this item. This mean that science teachers in middle schools do not give the students choice to select the content or the learning activity which they see as relevant for them. This result may have attributed that teachers tend to maintain their control over the teaching process and may attributed to their perspective that they are more likely know the objectives and requirements based on the curriculum. This finding is inconsistent with Patall et al. (2010) who points out that offering for such choice in the classroom has been found to be related to higher intrinsic motivation, engagement, sense of competence, and academic achievement. This finding is also inconsistent with Krumholz (2000) who notes that if we want to apply a constructivist view in learning it is requires to give the freedom to the student to choose the subject in which he is interested, as well as freedom and creativity in organizing the material and in selecting strategies and learning activity.

Regarding the *knowledge construction* component which has mean value of 2.92. This value means that science teachers in middle schools implement *frequently* the component of *knowledge construction* which is the basic principle of the constructivist learning approach. By using this approach student construct his knowledge by his own so this knowledge can extend its retention in student long memory and retrieved to be applied in solving problems and reasoning. This finding show a positive point of view towards meaningful learning. The item no. 8 "Students are given the opportunity to make connections between concepts they already know and concepts that will be learned in the future" received the highest mean value of 3.14. This value as it classified means that science teachers in middle schools implement *frequently* the activity described in this item. Teachers are aware about the importance of prior knowledge in knowledge construction. Based on this, new knowledge linked to the prior knowledge to generate multiple representations or models of knowledge that can be used in problem solving. This finding is supported by Michael & Modell (2003) who notes that the ability to generate multiple representations of knowledge being learned and to connect the students' prior knowledge to new knowledge, both are a sign of deep understanding that enables students solving problems in a different situation by using this knowledge. This finding supported also by Hammond (1992) who points out that people learn best when they make connections between what they already know and what they learn and when they see how ideas relate to one another and when they can use what they learn in concrete ways.

The practice of the *critical thinking* component has mean value of 3.17. This value means that science teachers in middle schools implement *frequently* the component of *critical thinking*. This result show that science teachers support teaching that develops high order thinking such as critical thinking. Thinking skills contributes to the construction of students' knowledge and helps them to move from learning that emphasizes memorization to learning that emphasizes the construction of knowledge in meaningful ways. The item no. 13 "Students are given the opportunity to doubt/ask about information, that is confusing them, for clarification" received the highest mean value of 3.5. This value means that science teachers in middle schools implement *always* the activity described in this item. Science teachers allow students to examine any information they encounter. This helps the teacher to expose the students' misconceptions, and gives teachers an opportunity to assess the students' understanding of the subject. This finding supported by Ennis (1985), as he notes that people who are critical thinker should have the abilities to ask and answer questions for clarification and making decisions about "what to believe" and "what to do" or solving problems (Ennis, 1985).

Item no. 14 is received high mean value of 3.45. The activity in this item states that "Students are given the opportunity to present ideas from different points of view, such as to present various options to solve a problem". This value means that science teachers in middle schools implement *always* the activity described in this item. This result shows that teachers believe that giving alternatives or options in solving problems may facilitate the students' creativity and helps them to use the knowledge they have in various situations. Supporting this by Ennis (1985) who asserts on the importance of taking into consideration different points of view to explore alternatives (Ennis, 1985).

The practice of the *feedback* component has mean value of 2.98. This value as it classified means that science teachers in middle schools implement *frequently* the component of *feedback*. This finding, according to science teachers, shows the importance of implementing continuous assessment accompanied with effective feedback during the teaching and learning processes. Many schools today perform high-frequency mapping tests to gather information about the knowledge, skills, and understanding that students have acquired before, during and after their learning. Based on the feedback from ongoing assessment, learners and teachers become aware of gaps that exist between the desired goal and the current learning outcomes. This feedback guides them through actions necessary to improve their learning and obtain these goals. These actions include intervention plans adapted to different students who have common misconceptions or misunderstanding that require improvement and correction.

The item no. 25 "Students' understanding is assessed continuously during and in the end of the learning process" received high mean value of 3.23. This value as it classified means that science teachers in middle schools implement frequently the activity described in this item. Continuous assessment enables diagnosis of learning gaps, so they can be addressed before they lead to more fundamental misunderstandings of knowledge or misapplication of skills. This finding is in line with OECD (2008b) report that points out that to evaluate deeper understanding, it is essential to assess continuously the extent to which learners' knowledge is integrated, coherent and contextualized. In this way, teachers examine whether meaningful learning has occurred or not.

Item no. 22 "Students use feedback based on self-assessment to promote and improve their learning" received the lowest mean value of 2.6. This result may have attributed to the fact that most teachers don't have the tools how to apply self-assessment among students to improve students' outcomes, this interpretation can be supported by the finding of item no. 21 which also received low mean value of 2.76 which states that "Students are given the opportunity to assess their own learning progress", this mean that giving opportunity to the students to make self-assessment is relatively low. This result may explain why students not use feedback from self-assessment to improve their learning. It is may be attributed also to that this process needs continuous monitoring by the teacher, hence it may needs invest time and efforts for the teacher. According to Harlen (2006), self-feedback promotes internal motivation and a sense of efficacy. Earl (2013), also pontes out that students learn to take control and responsibility of their learning by defining learning goals and monitoring their progress in achieving them.

Teachers reported also that during the past year, students have been given the opportunity to experience *learning by doing* with mean value of 3.24. This value as it classified means that science teachers in middle schools implement *frequently* the activity described in this item. This finding shows that teachers emphasized on implementing teaching methods that combine doing in the learning process such as experimenting, projects and inquiry and more, this can be attributed to the fact that the science curriculum set special emphasis on this issue in schools and tracking of the Ministry of Education after its application. These approaches make learning enjoyable for students and deepen their understanding of the learning material. A proverb attributed to Confucius asserted the importance of learning by doing by the following statements: "I hear and I forget. I see and I remember. I do and I understand". This quote expresses the effectiveness of the experiential learning.

*learning based on teaching* is another approach of self-learning. In this approach, students learn a topic by their own and teach or explain it to other students. This approach received mean value of 2.95. This value as it classified means that science teachers in middle schools also implement *frequently* the activity described in this item. It is attributed to that teachers emphasize on giving the opportunity to their students to take the role of the teacher to teach other students. This opportunity allows learners to boost their motivation to learn, take more responsibility of their learning, enhance creativity, reinforce self-confidence, dealing with high order thinking skills, generate knowledge, seek information, develop presentation and internet skills and promote mastery of self-regulation.

**Research question 2: Correlations between practice and beliefs of PCML**

In general, the *practice* mean value of each PCML were lower comparing with the *beliefs* mean value of the same component. It can be concluded also that the mean value of the *practice* of the whole components were lower comparing with the *beliefs* of the whole components. However, based on the findings, in general, there was a significant positive correlation between beliefs and practice of the whole pedagogical components of meaningful learning ($r = 0.335$, $p < 0.001$), which means, as the beliefs of the whole PCML increases, the practice of the whole of these components increases. As well, it can be concluded also that there are strong and moderate connections between the beliefs and the practice of each pedagogical component of meaningful learning except for the component of the *knowledge construction*. In other words, teachers hold positive beliefs and attitudes toward meaningful learning as well they implement its various components. The more the science teachers believe in meaningful learning and its components, the more they would provide for the students the opportunity to practice meaningful learning in class.

This finding can be supported by Ernest (1988) who argued that teachers' beliefs have a powerful impact on the practice of teaching (Ernest, 1988). Another research evidence has shown that teachers' beliefs about teaching and the learning of science influence their teaching practices (Fang, 1996; Laplante, 1997). Clark and Peterson (1986) described teachers' beliefs and theories as "the rich store of knowledge that teachers have that affects their planning and their interactive thoughts and decisions" (Clark and Peterson, 1986).

The correlation between science teachers' beliefs and their practice of the component *feedback* received the highest value of 0.268, this means that teachers have high positive relationship, comparing to other components, between their beliefs and their practice of using *feedback* in their teaching-learning process. In other words, it means that the more the science teachers believe in *feedback*, the more they would provide for the students the opportunity to practice *feedback* in class.

However, the correlation between science teachers' beliefs and their practice of the component *learning based on teaching* received the lowest value of 0.164, this indicates that teachers have low positive relationship, comparing to other components, between their beliefs and practice of *learning based on teaching* in their teaching science. This finding indicates that science teachers have positive attitude towards *learning based on teaching* but they do not implement it in the class in the same or close level as they believe in it. This can be attributed to the tendency of teachers to control the course of the lesson. Another reason may explain this finding is that teachers do not have the sufficient knowledge, competence or time to guide their student to use this approach of learning.

The results indicate that there is no correlation found between science teachers' beliefs and their practice of the component *knowledge construction*. It means that teachers believe in giving the opportunity to the student to build their own knowledge but there are some factors that hinder them to apply this in their lesson. One of these factors may be attributed to the egocentric role that play the teacher which stem from the desire to control the course of the lesson. another factor may be attributed to poor knowledge or skills that science teachers possess in order to design activities which based on the constructivist view of learning. It also may relate to that not all students are directed for this activity of *knowledge construction* and it depends on students' background characteristics.

At the item level, we can find significant differences in teachers' responses on particular item in term of their beliefs about what is described in that item comparing to what they actually apply in their class. For example, in the *relevance* component item no. 3 which related to the case of giving opportunity to the student to choose the content or the learning activity according his preference, this item received in the practice section a low mean value and it was equal to 1.78 at the time it received a high mean value of 3.25 in the beliefs section. In terms of percentages, only about 16% of teachers reported that they implement this activity in their classrooms while 90% of teachers reported that they believe in this activity. In other words, most teachers believe in giving students the opportunity to choose content or learning activities at a time when most do not do so in their classrooms in science lessons.

The feedback component also shows a significant difference between teachers' reporting of what they believe and what they implement. For example, in item no. 22 which related to the case of students use feedback based on self-assessment to improve their learning received a low mean value of 2.6 in the practice section while it received mean value of 3.44 in the beliefs section. In terms of percentages, only 58% of teachers reported that they give this opportunity to students in their actual teaching, compared to 94% of teachers believing in this activity. In other words, most teachers believe in giving students an opportunity for feedback based on self-assessment to improve their learning at the time a relatively low percentage of them practice that activity in their classrooms in science lessons. Similar findings can be seen in other components such as the *critical thinking* and knowledge *construction*.

The implication of that is that it is not sufficient that teacher believe in certain activities that promote meaningful learning, there are probably other conditions that depend on the system, infrastructure, students, school space and teachers themselves that can influence the implementation of these activities. Some of these conditions were mentioned in the qualitative part of this study in the fourth and fifth research questions. This conclusion can be a basis for conducting future study to examine the influence of various factors, including those mentioned in the qualitative section, on the implementation of activities that promote meaningful learning.

**Research question 3: Correlations between practice and teachers' background variables**

The findings indicate that there were no statically significant differences between the mean values of teachers' practice of the whole components of meaningful learning attributed to their gender, years of teaching experience, type of school and educational qualification. This may be attributed to that meaningful learning reform is a systemic reform that presented to all teachers in all schools by teachers' training, digital resources or written documents regardless the differences in gender, teaching experience, educational qualification and type of schools. The extent to which the components of meaningful learning implemented are more likely depend on other factors that relate to teacher such as beliefs, skills, knowledge, training, readiness to lead change, motivation, job satisfaction, etc... The finding may be related also to other factors refers to student and system characteristics.

Findings indicate that there were statically significant differences between the mean values of the teachers' practice of *knowledge construction* and the teachers' practice of the *learning based on teaching* components attributed to their gender in favor of female teachers compared to male teachers. It means that female teachers tend to provide the opportunity for the students to construct their own knowledge and to learn based on teaching more frequently than male teachers do. These findings may be attributed to that female teachers do not see students' involvement in learning activity as threatening factor rather than as a partner in building his own knowledge. Females from the motherhood aspect have the ability of patience and endurance to accommodate student needs, thus they tend to give the opportunity to the students to discussion, dialogue, ask questions and engage him in various learning activities to construct his/her knowledge.

The findings indicate that there were statically significant differences between the mean values of the teachers' practice of the *relevance* component attributed to school type in favor of teachers in state schools compared to teachers in private schools. This may be attributed to the fact that the teachers in state schools are committed to training offered by the Ministry of Education, these trainings focus on connecting education to the life of the student. There is more participation of teachers in this kind of training and they are motivated in return due to an increase in salary. In addition, there are greater human and material resources available in state schools, with extra hours for teaching which allow individual work with students such as learning in small groups that allow close relationship between teacher and their student in addition to learning visits to the museum, factories, academic centers. As well as, participating in projects subsidized by the ministry of education which aim to connect education with the students' life and the society in which they live.

In addition, a statistically significant difference was found between the mean value of the teachers' practice of the *feedback* component in favor of teachers in state schools compared to private schools. This finding can be attributed to the fact that private schools are selective (usually those belonging to the Christian church which are informal recognized schools) where the student population is sorted and classified according to academic achievement. Typically, the students in these schools are characterized by high socioeconomic status and parental support and involvement. Furthermore, the private schools usually have high level of competitiveness among students. However, the private schools do not receive extra hours for groupings or individual work which is designed based on continuous monitoring and feedback. These data may reduce the need for subsequent follow-up by conducting frequent tests for feedback to deal with individual or group work adapted to the students' needs. Students in State schools, on the other hand, are usually have low academic achievement, limited parental support and relatively low socioeconomic status comparing with students in private schools. The Ministry of Education use what is called "affirmative instruction" in state schools by the provision of material and human resources to close the gap with private schools. The students in state schools require teachers to keep monitoring the students' progress, which requires ongoing assessments and constructive feedback from these assessments to build adapted intervention programs with a view to improve teacher work and promote student learning. Therefore, the availability of these allocated resources allow teachers to conduct these assessments more frequently and receive feedback to regulates the teaching and learning process to achieve the goals and objectives set by the Ministry of Education.

**Research question 4: Conditions for enhancing meaningful learning**

This question focused on identifying conditions which may enhance meaningful learning in science teaching according to science teachers opinion in middle schools. In this study I focused on three kinds of conditions as follow: pedagogical conditions, administrative conditions and conditions associated with students.

**Pedagogical Conditions:** Through analyzing the contents of the *pedagogical condition*s, five themes were emerged from the responses of participants. These themes are ordered by descending order according to their percentages of responses as following:

**Application of Digital Tools.** Most teachers in the interviews emphasized the need to increase the frequency of the use of digital tools in science lessons. The tools were mentioned in the interviews are simulations, animations, videos, cellular telephones and computer experimentation. Interviewees suggested that these tools are needed to illustrate abstract concepts, stimulate understanding and internalize the learning material, present, clarify, explain phenomena, processes or structures as well as using these tools for assessment. Teachers today, have the point of view that technology can be served as an assistant tool to teachers to plan unusual lessons which include attractive activities which can capture the students' interest such as simulations, animations, videos and so on. By using digital tools, we bring the content under study closer to the real-world of the students. In addition, the various possibilities that digital tools offer could cope with the students' heterogeneity in the class. The knowledge and skills that most teachers have today in working with technology and the relevance of these tools to the students can boost the teachers' and students' motivation to use these tools in learning science. This finding is supported by the professional literature, which emphasizes the need of using technological tools to promote meaningful learning. Ashburn and Floden (2006) emphasize in their book "Learning with Technology" that technology works for students as an intellectual partner that helps them to promote thinking, learning and understanding of the world in which they live. Learning with technology will advance meaningful learning if it is based on learners' involvement in building knowledge, discussion, self-expression of acquired knowledge, And the use of reflective thinking. McLoughlin and Lee (2007) emphasize the contributions that social media (one of the digital tools) can make to learners’ desires to participate and connect with peers, teachers, subject-matter experts and the community. They also recognize that social media can support meaningful learning through connection, collaboration and shared knowledge construction (McLoughlin and Lee, 2007).

**Exercising Various Teaching and Assessment Methods**. Half of the teachers emphasized the need of using a wide range of teaching and assessment methods to promote meaningful learning. The methods mentioned include: laboratory experiments, learning by inquiry, building models for illustration, learning through games, project based learning, extracurricular learning, observations, visits to museums or industrial plants and others. The diversity of teaching and assessment methods copes with the diversity in backgrounds that students in middle school come from. This diversity offers to the students the choice to adapt the appropriate method according to his preferences and serve as a way to cope with heterogeneity in the class. These teaching methods involve the student in the learning activity mentally, socially and physically.

It is important to mention that in the interviews teachers did not refer to how many of these methods were implemented in such a way that would give maximum value to the student's understanding and learning experience. Therefore, future evaluation research is needed to examine the quality of implementation of these teaching methods and how it affects their learning outcomes.

This finding is supported by Herpaz (2014), who argued that the most basic principle of teaching that allows meaningful learning is the use of indirect teaching patterns as those mentioned above. These teaching patterns increase the active involvement of knowledge constructing and the creation of understanding by the student himself (Herpaz, 2014c). This finding is align with a study conducting by RAMA (2018) based on interviews conducted with teachers from different subject areas. Teachers in these interviews claimed that meaningful learning should be based on diverse teaching methods and alternatives in assessment (RAMA, 2018).

**Assessment for Learning.** Half of the teachers talked about the need to use assessment to improve learning and teaching processes. They referred to the assessment for learning in terms of the following: conducting frequent tests to monitor students' progress, emphasizing on assessing students' understanding by questioning and discussion during the lesson and clarifying the points that were not understood by the students, focusing on a written constructive feedback on student's work in addition to marking and focusing on self-assessment by providing an opportunity for the students to assess themselves and reflect on their work.

Assessing students' understanding during learning is an important element of meaningful learning. Monitoring learning progress and receive feedback that allow students to regulate their learning is essential to improve their own understanding. Research shows that assessment for learning is one of the most important strategy to promote meaningful learning and to raise learner achievement (Assessment Reform Group, 2002). Optimal assessment for learning process promotes thinking and problem-solving skills (Black & Wiliam, 2006) and raises the motivation for deeper learning (Harlen, 2006). The Ministry of Education documents (2018) also emphasize the importance of ongoing assessment that provides teachers and learners with information on the development of the learning process and enables meaningful feedback to assess learning during and after its emergence to make decisions about teaching improvement (Israel, Ministry of Education, 2018).

**Implementation of Constructivist Learning Principles**. Science teachers in the interviews suggested pedagogical principles that are align with constructivist view. Science teachers hold constructivist point of view that would play a main role in implementing meaningful learning in science teaching. The first principle suggested in this study was the *knowledge construction principle*. According to science teachers, students should construct their knowledge through inquiry and self-learning. They suggested that students need help to connect previous learned material to the new material. Teachers emphasized also on the development of higher order thinking skills such as building arguments, drawing conclusions, asking questions, understanding the relation between effect a result, analyzing data and constructing hypotheses and examining them. It is clear that through constructivist instructional approaches, students go through several thinking skills to build their own knowledge. This knowledge can be transferred in new context, by doing this, students involved in constructing meaning.

This finding supported by Forbes & et al. (2001), who points out that constructing knowledge is important for students' learning because it ensures students are experiencing meaningful learning (Forbes, Duke, & Prosser, 2001). Knowledge construction involves building mental models or representations of "real world" that can be used to solve problems. The ability to generate multiple representations or models of knowledge being learned and to connect them to prior knowledge, is both a sign of deep understanding and important component of meaningful learning because it enables students solving problems in a different situation by using this knowledge (Michael & Modell, 2003).

The second principle is the *active principle*. It exposed in the interviews as follow: students participate in projects and inquiries, experiments, discussions and solving problems. Science teachers support and encourage students' involvement in the learning process. This finding is important because new approaches of teaching focus on student-centered learning in which the student takes an active role in constructing his own knowledge and understanding that will be meaningful for him. This finding is align with Frymier & Shulman (1995) who points out that students' active involvement in constructing their own ideas is essential to promote meaningful learning (Frymier & Shulman, 1995). This also supported by Newmann (1996) who asserts that studies have shown a positive impact on learning when students participate in lessons that require them to construct and organize knowledge, consider alternatives, engage in research, inquiry, writing, and analysis, and to communicate effectively (Newmann, 1996).

The third principle is the *cooperative principle*. Some teachers expressed the need for cooperative learning as follow: in some learning activities students divided into small groups, students cooperate with each other, students make discussions to solve problems, students share explanations and ideas with each other, students collaborate in summarizing information from a text, they play roles, etc… It is become clear that cooperative learning involves activities that promote learning, these activities can be elaborated to activity such as sharing ideas, dialogue and discussion with peers, mutually searching for understanding solutions, building product, exposure different point of view, defend their positions and participate in higher order thinking. These activities will deepen students' understanding and make students responsible for each other's as well as their own. Supporting this, Mintzes and Wandersee (1998) claim that peer-peer discussions in co-operative learning groups can promote meaningful learning by helping learners to help each other to incorporate new experiences and information into their existing cognitive structures in a non-arbitrary and non-verbatim way (Mintzes and Wandersee, 1998). Learners are more engaged in learning and can tackle bigger, more sophisticated projects when they collaborate with others both inside school and within and between communities (Century Curriculum and Instruction, 2007).

The fourth principle is the *relevance principle*. Some teachers indicated to relevance as crucial component to achieve meaningful learning. Without making learning relevant to student the content under study will not be meaningful for him. They asserted that teachers should make the content learned valuable and relevant to the student by empowering students with values, explaining to the student why they learn a particular topic, how the topic they learn relates to other topics in daily life or lifelong learning, how learning connected to personal interest and giving them choice to decide what to learn. Studies show that meaningful learning occurs when students are motivated to invest efforts in learning (Pellegrino & Hilton, 2012) .When students are motivated to learn, they try harder to understand the material and thereby learn more deeply, resulting in better ability to transfer what they have learned to new situation which indicates meaningful learning (Mayer, 2002). According to Keller (1983) relevance known as one of the key terms related to foster motivation which is considered as a crucial element for promoting meaningful learning.

**Differentiated Instruction.** Differentiated instruction is a teaching approach that provides a variety of learning options to accommodate differences in how students learn. Differentiated teaching was expressed in this study according to the science teachers' perspective as follow: adapting the learning styles to the students according to their preferences, taking into considerations the differences in student learning cognitive levels or abilities, giving the students' choice to choose the appropriate assessment method, etc… The teachers in the interviews, referred also to the advantages of this kind of instruction such as students make progress according to his level, students increase their engagement in learning, etc... It is obvious that pedagogy that refers to the students' differences and adapt teaching to their needs, makes learning more relevant to the student and thus increases his or her involvement in the lesson, this approach will allow students to experience meaningful learning. A study aimed to determine the effect of differentiated instruction on learning outcomes of high school science students show that teachers perceived differentiated instruction as an effective instructional method for improving student engagement and academic performance (Pablico, J., Diack, M. & Lawson, A., 2017). Another study conducted by Burkett (2013) on differentiated instruction, show positive emotional outcomes in this kind of teaching in terms of motivation, task commitment, and excitement about learning (Burkett, 2013).

**Administrative Conditions:** Six *administrative* conditions (themes) were identified. These themes ordered by descending order according to their percentages of responses as following:

**Resources**. The availability of physical/material and human resources was the most essential condition that have pointed out by science teachers in order to establish meaningful learning. The physical/material resources addressed by the teachers are: teaching hours, availability of laboratory, computer rooms, learning centers and learning spaces, training and guidance hours and budgeting extra-curricular activities. The human resources proposed by teachers as additional conditions for meaningful learning are: laboratory and computer technicians. It is obvious that every school must take care to mobilize these resources so that they can implement meaningful learning successfully. It is impossible to lead to successes of the reform without these resources. This finding is consistent with the finding of an evaluation study conducted by RAMA (2018) showed that one of the contributing factors to an environment that promotes meaningful learning is the existence of physical resources such as those mentioned above (RAMA, 2018).

**Principal Support**. According to the science teachers' responses, meaningful learning cannot occur without the support of the principal, the support of the principal is a necessary condition for the advancement of teaching and learning processes, the principal's support enables the teacher to mobilize his powers in order to lead fruitful and successful pedagogical processes. Most teachers emphasized the importance of the support of the principal as follow: supporting the decisions of the teacher to lead a change, supporting the teacher in any project that will give the student an opportunity for self-learning, giving full authority and appreciation to teachers, readiness to develop the learning environment, giving opportunities that contribute to the development of 21st century skills, giving pedagogical flexibility and decision-making for teachers.

Obviously, the school principal is the one who makes the crucial decisions at school. He is the leader of the educational process, he is the one who can prepare the ground for program growth, including the meaningful learning program, he is the one who can build, activate or expedite the meaningful learning process in the school and he is the one who can also place barriers and obstacles to hinder its promotion. He needs to be convinced of the change and deepen the collaboration with the teachers and concentrate the efforts of the skilled teachers to promote meaningful learning. Studies have shown that teachers are the most influential factor in student achievement. This also supported by Hattie (2009) who asserted that teachers are among the strongest influences in learning. In addition, McKinsey report states that "learning cannot be improved without improving teaching" (Barber, 2007). These studies showed that teachers are an important element to promote students' learning, Thus, principals' supporting is necessary for teachers to success in their missions to implement instruction that enhance meaningful learning.

**Professional Development.** Most teachers suggested to expand science teachers' knowledge and skills to enhance meaningful learning by their enrollment in professional development. As well as, to monitor the extent of implementation in their classes. The need for professional development was expressed as the following: teachers need for professional development and practical training for implementation of meaningful learning in the science lessons, teachers' knowledge and skills need to be updated according to the changes in the curriculum through professional development, teachers need to learn an innovative teaching methods and practices such as learning through games, learning through inquiry and digital pedagogy. These strategies make learning more relevant and enjoyable to the student.

This finding indicates that teachers believe in the need for additional training for teaching for meaningful learning. Meaningful learning is a broad issue that includes various components and the teacher should be well prepared for this type of teaching. Usually, one professional development cannot encompass all the components of meaningful learning. Therefore, teachers should first of all be aware of the whole components of meaningful learning and enroll in the relevant courses. Professional development by itself is not enough to promote meaningful learning, the teachers should be well-intentioned, ready for change and have positive believe in the process and have the competence to use the knowledge he has acquired in the professional development to apply in their class. The innovative teaching approaches mentioned above require long training and practical experience in order to achieve the desired results.

**Curriculum.** Almost half of the teachers referred to the importance of adapting the curriculum and updating it to requirements that allow meaningful learning. The teachers expressed that as follow: reducing the learning materials in the curriculum in order to conduct more experiments and inquiry or project based learning because these methods require too much time; selecting interesting, attractive and relevant contents from the students' real world and compatible with daily life; adapting the materials in the curriculum to the students' age; reviewing and updating the curriculum contents, skills and values to the 21st century.

**Autonomy and Flexibility of the Teacher Role.** Flexibility and autonomy in the teacher role is one of the conditions that half of the interviewees indicated in order to enable teachers to enhance meaningful learning. The interviewees expressed the need for autonomy and flexibility in the role of the teacher as described: autonomy to the teacher to choose what content or topics students should learn; to choose the appropriate teaching methods for students; to select various teaching tools relevant to the lesson, flexibility in choosing the assessment methods and tools and giving space to the teachers to be creative and to work outside the box. Studies have shown the great influence of the teacher on their student achievement and learning. Therefore, the teacher needs a framework that allow him freedom of choice and autonomy to adapt the teaching processes to the school conditions and the characteristics of the various student groups. According to the interviewees responses, giving teachers autonomy and flexibility allow enhancing meaningful learning.

**Professional Team Collaboration.** Another administrative condition for promoting meaningful learning offered in the interviews is the collaboration between the teachers of the professional staff. The interviewees pointed out the importance of team collaboration by emphasizing on cooperation and dialogue between the members of the professional team, developing a learning community, sharing ideas, mutual encouragement and support among the staff, collaboration in dealing with common issues, preparation of shared lesson plans based on the principles of meaningful learning, pleasant atmosphere between the professional staff, a respectful relation and mutual trust.

The actions mentioned above strengthen the teamwork and allow for sharing ideas, planning and making reflection on what is done in the classroom. Teamwork will lead to self-realization and success. Creating a learning community which learn from successes and failures of teachers' experiences is important to improve teaching and learning outcomes. Each teacher has different experience, different characteristics, different academic backgrounds, different training and different skills that are mutually shared each with his colleagues in the professional team and it will contribute to enrichment and the success of the collaborative work.

**Conditions Related to Students.** The interviewees suggested conditions related to students to promote meaningful learning as described as the following:

1. Motivation to learn.
2. Open mind and responsibility.
3. Awareness of the importance of sciences to real and future life.
4. Previous knowledge of the content under study.
5. Basic skills such as reading and writing ability, computer use, self-learning ability, knowledge of scientific inquiry principles, basic knowledge of working on a computer.
6. Normal socioeconomic status.

The presence of these conditions will form the basis for embedding successfully the external pedagogical processes that depend on the teacher and the system. For instance, without the students' motivation, meaningful learning will not be realized, because motivation is a key condition for meaningful learning. Students also should be able to read or write or to use a computer and internet, otherwise they will not have confined ability to learn. In addition, students should have a prior knowledge to be able to construct their new knowledge. The students should be responsible for learning, they should be directed for self-learning, initiative, set goals, plan and evaluate their learning so it become more meaningful.

**Teacher-Student Relationship**. Teachers-student relationship also suggested as a condition to enhance meaningful learning. This condition was emerged from the overall contents of opinion that teachers expressed in the answers of the all three sub-questions. Teacher-student relationship is an important condition for bringing students closer to the teacher. The interviewees pointed out that teacher should accept the student as he/she is, teacher must be supportive, encouraging and loving for students, good relationship between the teacher and the student motivate to learn, teachers must be close to the students' world and their interests, teachers must give constructive feedback to the student, teachers must give students material and moral reinforcements, understand and know their needs.

Best teacher-student relationship allows teachers to recognize the student's unique needs and help student to mobilize his motivation to learn science and to adapt to the best teaching methods. This finding is supported by a study conducted by Hughes, Luo, Kwok, and Loyd (2008) shows that the quality of teacher–student relationships in reading and math classes leads to behavioral engagement in those classes, which in turn leads to higher achievement in these subjects (Hughes, Luo, Kwok, and Loyd, 2008).

**Research question 5: Obstacles hindering meaningful learning**

The fifth research question aimed to expose the obstacles that hinder the enhancing of meaningful learning in science teaching according to science teachers opinion in middle schools. Through analyzing the contents of the teacher's opinion, five themes were emerged from the responses of participants. These themes ordered by the descending order according to their percentages of responses as the following:

**Teachers' Beliefs.** According to the professional literature, teachers' beliefs and perceptions may affect the implementation of instructional practices that promote meaningful learning.  Most interviewees emphasized that as follow: teacher's lack of readiness for change and development in their field, teachers perceive professional development as source of expanding their knowledge but not for implementing in their lessons, teachers adopt the perspective of transmitting knowledge rather than constructing it by students himself.

If one teacher does not believe in the benefits of professional development or does not ready for change in professional life or who does not want to adopt innovative teaching practices, he will not be able to apply meaningful learning principles. For example, a teacher can develop professionally in meaningful learning, but he does not intend to apply what he gained in the professional development in his classroom for the reason that he believes that teaching practices that promote meaningful learning do not fit the student population in the classes he teaches. In cases of beliefs that affect negatively the implementation of meaningful learning, brainstorming, dialogue asking and seeking solutions, teacher collaboration time, and principal support all can change the negative thoughts that hold teachers which hinder the implementing this type of learning.

**Lack of Professional Qualification.** The majority of teachers in the interviews asserts on the professional qualification as the source of gaining knowledge and skills for promoting meaningful learning in teaching science. The interviewees emphasized the lack of teacher professional training for meaningful learning as a hindrance to its occurrence. They pointed out that teachers do not have the tools and competencies to lead meaningful learning, teachers are with limited abilities and minimal knowledge insufficient to lead to meaningful learning, teachers may find difficulty in implementing innovative teaching strategies and methods, teachers may not have the sufficient knowledge how to develop higher-order thinking skills among students and difficulty in dealing with heterogeneity in class (differentiated instruction).

One of the conditions suggested by teachers in the findings of the fourth research question in this work to enhance meaningful learning is to undergo professional development that focuses on principles and teaching practices that promote meaningful learning. This condition is probably due to the fact that the interviewees see the lack of teachers' training for meaningful learning as presented in the findings of the fifth question.

**Educational Workload.** Some teachers reported that workload is an obstacle that may hindered meaningful learning. Teachers' expressed the impact of workload as follow: workload prevents deep learning, teachers required to cover high quantity of material which make it difficult to teaching for understanding, investing efforts and time for preparing for external test and mapping tests, workload emerged from preparing work plans and filling out reports.

As we know, teachers have many tasks that they sometimes have to finish at home. Teaching indeed is a main part of the teacher's role, but in addition to teaching, teachers have other roles that they need to fulfill, such as meetings with students, parents, professional staff or exam testing. As well, teachers are required to complete educational and learning reports aim to monitor each student. Teachers are also required to attend a professional course each year after their working days. The meaningful learning program requires teachers to expand their pedagogical knowledge and become familiar with teaching and assessment methods that they did not use before, this requires considerable time and effort. In addition, science teachers in middle schools complain of workload due the 'Mitzav' test of the Ministry of Education. Teachers need to cover the material included in the exam and they usually will not have enough time perform that, the result is that teachers will use teaching methods that are based on knowledge transmitting and not methods based on constructive approach or focus in deep understanding. This finding was supported by Yehieli (2007), who argues that "as long as there is (internal or external pressure), the teachers must complete material, teachers are more likely to lecture and transmit the contents, and it is harder for them to be directed to encourage meaningful learning in their students".

**High Class Size.** Some of the interviewees noted that the high class size is an additional condition that could hinder the implementation of meaningful learning. Teachers' expressed the impact of high class size as follow: high number of students in the class makes it difficult for the teacher to reach every student, high number of students in the classroom limits the teacher to use teaching/assessment methods that promote meaningful learning.

In order to enhance meaningful learning in teaching science, the class climate needs to be adapted to this kind of learning. To create meaning for what is taught in the classroom, the number of students in the classroom should be as minimal as possible for the reason that this situation allows the teacher to reach each student. This can be done by preparing lesson plans adapted for the different students. A small class enables the monitoring of each student and enables teaching practices to be implemented with learning through inquiry or laboratory experiences, group discussion or digital learning. Indeed, the Ministry of Education has been working to reduce the number of students in classrooms and it maximized the number in class up to 32 (it is the case in state schools). Probably science teachers in state schools feel that there is still the possibility of additional reduction of the number of students in the classroom, because in science, there is a need to more hours in the lab and computer rooms which require learning with minimum students. In addition, a teacher cannot control even 32 students alone to create meaningful learning, so one of the conditions suggested by the teachers for meaningful learning is the human resource. In other words, teachers need another assistant in the lab and computer rooms for guiding students and fix possible infrastructure failures during learning. The situation is worse in private schools where the number of students reaches 38 or 40 with reduced teaching hours in science. These conditions make the implementation of meaningful learning in these schools almost impossible.

This finding is supported by Yehieli (2007), who argues that "if the teachers understand that they have to direct themselves to the students' cognitive structure, which is a condition of meaningful learning according to Ausubel, the more students there are in the class, the more difficult it is".

**Personal Students' Characteristics.** Some of the interviewees pointed out that there are characteristics related to the student himself that may inhibit meaningful learning. Among these characteristics: student's population with disciplinary problems, limited cognitive ability of students, low socioeconomic status and lack of parents' support. These are the basic background conditions that should be available to give the student the motivation and the desire to learn. Every factor introduced above play crucial role in hindering learning in general and meaningful learning in particular.

## 2. Limitations and Suggestions for Future Research

There were some limitations that had been recognized in this study. In this section, the researcher raises some recommendations for future research. Some suggestions are needed to develop and expand this study.

1. A larger sample size will be better when applying the questionnaire in all Arab middle school teachers in the country (to include the center and the south districts). Results would be more informative and more generalizable.

2. Only quantitative methods were used in the study to assess the actual practice of pedagogical components that enhance meaningful learning. The results were based on statistical data and analysis without in-depth qualitative data and analysis. If some qualitative methods were used such as interviews and observations, people would gain more insights about the actual practice of the PCML.

3. Evaluation the quality of the practice of PCML is needed by examining their impact on students' understanding and their attitudes.

4. This study treated some of the PCML and not cover the whole components due the broad aspects of this topic. Thus this study could be elaborated to more components of meaningful learning.

5. According to the literature, the beliefs and the practice and the relation between them, could be affected by contextual variables such as: class size, workload, professional qualification and others. Thus, future research can consider the influence of these variables when we want to examine the relationship between beliefs and practice.

6. Because science teachers have their own distinct perceptions, experience, and thoughts, the manner in which the perceptions are reflected may be different from teachers of other subject areas. Therefore, to allow generalizability and transferability this study could be extended to other disciplines.

7. The conditions presented by the teachers in the qualitative research, which represent conditions for the promotion of meaningful learning, would serve as the basis for future quantitative research in order to examine the degree of their presence in middle schools.

## 3. Conclusions and Recommendations of the Study

The study was designed on the basis of the researcher's interest to evaluate the status of meaningful learning in science teaching in Arab middle schools' classrooms in north Israel. The questionnaire was designed to assess science teachers' beliefs and practice of pedagogical components that are crucial for promoting meaningful learning. The items for specific component in the practice section are parallel to the items in the beliefs section for this component. In other words, the items of the same component in each section examined the same content but they appeared in different formulations in each section. As well as, the researcher also explored factors that influenced the practice of pedagogical components of meaningful learning (PCML) such as the teachers' beliefs and relevant personal and professional background factors. This study also intended to identify obstacles and suggests conditions that affect the implementing of meaningful learning. For this purpose, an interview was conducted.

Generally, the participating teachers reported relatively high positive beliefs towards PCML especially in the components of *learning by doing, relevance, critical thinking, feedback and they believe relatively less in learning based on teaching and knowledge construction* but not down to a low level. Besides, the participating teachers reported relatively high level of practice PCML in their classes, especially in the components of *learning by doing, critical thinking, feedback* and they practice relatively less often the *relevance, knowledge construction and the learning based on teaching* components but not down to a low level. However, the findings of this study raise the need for deeper understanding of the practice of PCML in several dimensions. The first dimension, we can't base our conclusions only on finding from quantitative research approach, this study cannot give us deep information on the actual frequency of practice of the PCML in science lessons, hence, the data needs to be considered prudently since teachers' report may be more positive than reality. The second dimension, this study does not provide us information to the extent to which these components implemented in effective and professional manner that will lead to the desired results for students' learning.

The mean values of the *practice* of each of the pedagogical components of meaningful learning were lower comparing to the *beliefs* of the same components. It also concluded that the mean values of the *practice* of the whole components were less than the *beliefs* of the whole components. However, the findings indicated to moderate correlations between the beliefs and the practices of the PCML, as well as a strong positive relationship between the general beliefs and the general practice of PCML. The findings also indicated that there were statistically significant differences in the practice of 'Knowledge construction' (KC) and the 'Learning based on teaching' (LBT) components attributed to their gender in favor of female. In addition, findings showed a significant difference between teachers in the practice of 'Relevance' (R) and the 'Feedback' (FB) components attributed to the type of school in favor of state schools.

Through analyzing the contents of the *pedagogical condition*s for enhancing meaningful learning (ML), five themes were emerged from the responses of participants as following: application of digital tools, experiencing various teaching and assessment methods, assessment for learning, implementation of constructivist learning principles and Differentiated instruction. Regarding the *administrative conditions*, six themes were identified as the following: resources, principal support, teacher professional development, curriculum, autonomy and flexibility of the teacher role and professional team collaboration. The *conditions associated with students* included: students' motivation to learn, having open mind and responsibility, students' awareness of the importance of sciences to real and future life, having previous knowledge of the content will be learned and various basic skills and normal personal and socioeconomic background. *Teacher-student relationship* is another important condition suggested by science teachers to enhance meaningful learning (ML) in middle schools. This study also exposed the obstacles that hinder the enhancing of promoting meaningful learning (ML) in science teaching. Five themes were emerged from the responses of participants such as: teachers' beliefs, Lack of professional qualification, educational workload, high class size and students' personal characteristics. These conclusions that can be drawn from such research can serve as a basis for improving the implementation of meaningful learning in science teaching and bring, over time, better achievements for individuals and society.

**Recommendations**

1. Science teachers in middle schools as they play the main role in the teaching-learning process are recommended to reflect on their practice of some activities such as giving the choice to decide what topics they are going to learn and which learning activities they will do or giving the opportunity to the students' for self-assessment and help them how to use feedback from this assessment to improve their learning.
2. Science teachers should try to find balance in practice of components especially in the light of their report of high level of positive beliefs in PCML in general.
3. Decision makers in the Israeli educational system recommended when they come to improve the implementation of meaningful learning (ML) to take into consideration the conditions and the obstacles suggested by science teachers.
4. It is recommended to give more hours for teaching science in private schools to allow them the practicing of the PCML that needs time and efforts.

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## APPENDIX A

## The Questionnaire in its Initial Form

## Research Questionnaire

Dear teacher,

My name is Elias, and I am a doctoral student in the department of education at ADAM MICKIEWICS University in Poznan – Poland.

I am doing research about teachers' thinking about teaching science in middle schools. The analysis of the research will help me to propose ways for improving science teaching in schools. This questionnaire contains two parts, the first part refers to background data, the second part contains statements regarding beliefs and practices in the context of science teaching in classroom. The questionnaire is anonymous and all data that will be collected is for research purposes only.

Your cooperation is essential to be able to present a reliable image to the subject that I search. If you feel discomfort while completing the questionnaire you may stop to fill. If there are questions or doubts regarding the questionnaire or the research, I will be happy to answer them by phone 0547373788.

I offer you my thanks in advance for your cooperation and your willingness to participate in the study.

The estimated time to fill out the questionnaire is 20-30 minutes. The questionnaire is formulated in the masculine form and is intended for both men and women.

Elias Abu Ghanima, researcher

### Personal Data-Part I

Please mark **X** in the appropriate box.

1. Gender: ☐ Male ☐ Female
2. Age: ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50+
3. Educational qualification: ☐ BA ☐ B.Ed. ☐ M.A ☐ M.Ed. ☐ Ph.D.
4. Seniority of teaching: ☐ 1 to 5 years ☐ 6 to 10 years ☐ 11 to 15 years ☐ More than 15 years

5. School Type (sector): ☐ State ☐ Private

**Beliefs and Practice-Part II**

1. Below is a list of items related to teaching and learning. Please indicate to what extent you agree or disagree with these items on the given scale: 1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree.

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Strongly disagree | Disagree | Agree | Strongly agree |
| 1 | The Prior knowledge of students does not play an important role when they learn new topic | | | | |
| 2 | Students learn better when they know how the content can be applied in a job or in daily life | | | | |
| 3 | Sharing students in selecting what topics or activities to be learned increases their involvement in the learning process | | | | |
| 4 | The teacher should explain explicitly to the students why it is worth for them to learn a particular topic | | | | |
| 5 | The Students learn better when the learning activity is focused around students' personal interest | | | | |
| 6 | The topics the students learn in classroom don't have to be related to their own personal goals or future job | | | | |
| 7 | Teachers should provide challenging tasks adapted to students' abilities that lead to success and excellence | | | | |
| 8 | The students learn more effectively if they relate the material they learn to what they previously learned | | | | |
| 9 | The students can assess their understanding of a particular idea presented in the classroom by rewriting and summarizing the idea in their own words | | | | |
| 10 | The students can succeed in learning content whether they use different thinking processes or not | | | | |
| 11 | Students learn best by finding solutions to problems themselves | | | | |
| 12 | Knowledge and skills learned in the classroom should be limited to implementation only in situations or examples presented in the classroom | | | | |

| Item | | 1 Strongly disagree | 2 Disagree | 3 Agree | 4 Strongly agree |
|---|---|---|---|---|---|
| 13 | The students should accept any knowledge or any skill presented in the class without giving them an opportunity to raise questions or present doubts on this knowledge or skill | | | | |
| 14 | The teachers should allow students to look at any phenomenon from a single point of view, such as providing only one explanation or one solution to the problem | | | | |
| 15 | The students must receive any information received from any source without the need to assess their reliability | | | | |
| 16 | Evidence gathered to support a particular claim should not be discussed whether it support the claim or not | | | | |
| 17 | Students should present the knowledge they have acquired by using one particular defined way | | | | |
| 18 | Students should give reasons to explain why their point of view is the right one | | | | |
| 19 | Students should not be required to bring contradictory evidence to ideas presented by others | | | | |
| 20 | Students should draw and justify conclusions from the research work they did before the teacher do so | | | | |
| 21 | Learning becomes more effective when students assess personally their learning progress | | | | |
| 22 | Students will be more successful if they use feedback from self-assessment to make improvement in their learning performance | | | | |
| 23 | Assessment of students' learning outcomes should be based upon predefined criteria/rubrics | | | | |
| 24 | Feedback from ongoing assessment plays a problematic and insignificant role in shaping learning activities | | | | |

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Strongly disagree | Disagree | Agree | Strongly agree |
| 25 | It is a waste of time to give detailed written feedback on students' work in addition to marking | | | | |
| 26 | Learning becomes more effective when teacher provide immediate feedback during their work on the task | | | | |
| 27 | Learning by doing leads to better understanding of the content | | | | |
| 28 | It is more useful to the student to learn by doing, compared to listening to the instructor lecture | | | | |
| 29 | Having to work within learning by doing make it harder for students to learn the content | | | | |
| 30 | Having to work within learning by doing invest more time and efforts, compared to learning by listening to a teacher's lecture | | | | |
| 31 | Students who learn by doing comprehend the material quicker | | | | |
| 32 | Students who teach other students in their class will understand the content better | | | | |
| 33 | It is more useful to the students to learn by teaching other students than learning by listening to a teacher's lecture | | | | |
| 34 | Having the opportunity to teach other students makes it hard for students to learn the content | | | | |
| 35 | Learning by teaching other students invest more time and efforts, compared to the learning by listening to a teacher's lecture | | | | |
| 36 | Students who teach a new content to other students comprehend the material quicker | | | | |

2. If you think about your current teaching during the current or last school year, please carefully indicate how often each of the following actions is reflected in the lessons you actually teach in your classroom on the given scale: 1. Never 2. Occasionally 3. Frequently 4. Always.

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Never | Occasionally | Frequently | Always |
| 1 | Students are given the opportunity to use knowledge that they already have in building new knowledge | | | | |
| 2 | Students are given tasks that allow them to apply their knowledge and skills to situations in their daily life or real world (out-of-school life) | | | | |
| 3 | Students are given the opportunity to decide what topics they are going to learn and which learning activities they do | | | | |
| 4 | I state explicitly why it is important to the students to learn a particular topic | | | | |
| 5 | I give a learning activity or a task, based on the students' personal interest | | | | |
| 6 | Students are given the opportunity to learn many things in the classroom that are suitable for personal goals or future student careers | | | | |
| 7 | Students are given various tasks and learning activities, adapted to their abilities and pace of learning | | | | |
| 8 | Students are given the opportunity to make connections between concepts they already know and concepts that will be learned in the future | | | | |
| 9 | Students are given the opportunity to rewrite the main ideas from books or other sources using their own words | | | | |
| 10 | Students are given the opportunity to apply various cognitive processes when they learn a content | | | | |

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Never | Occasionally | Frequently | Always |
| 11 | Students are given the opportunity to investigate real problems themselves and think of solutions to these problems before the teacher shows them how they are resolved | | | | |
| 12 | Students are given the opportunity to apply the knowledge and skills they have acquired in the classroom to new problems and situations | | | | |
| 13 | Students are given the opportunity to doubt/ask about information, that is confusing them, for clarification | | | | |
| 14 | Students are given the opportunity to present ideas from different points of view, such as to present various options to solve a problem | | | | |
| 15 | Students are given the opportunity to evaluate the reliability of sources of information they used | | | | |
| 16 | Students are given the opportunity to judge, if a given evidence supports a certain claim | | | | |
| 17 | Students are given the opportunity to interpret data in various ways such as: images, charts, graphs and tables | | | | |
| 18 | Students are given the opportunity to present arguments and provide reasons to justify them | | | | |
| 19 | Students are given the opportunity to give evidence that disconfirms other's ideas | | | | |
| 20 | Students are given the opportunity to draw and justify conclusions from a research work in which they have participated | | | | |
| 21 | Students are given the opportunity to assess their own learning progress | | | | |

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Never | Occasionally | Frequently | Always |
| 22 | Students use feedback from self-assessment to make adjustments to achieve the learning goals | | | | |
| 23 | Assessment of students' learning outcomes is based upon predefined criteria/rubrics | | | | |
| 24 | Learning activities are designed based upon feedback from ongoing assessment | | | | |
| 25 | Students' understanding is assessed continuously during and in the end of the learning process | | | | |
| 26 | Students are given detailed written feedback on their work in addition to marking | | | | |
| 27 | When students are working on the task they are given immediate feedback | | | | |
| 28 | During the last year the students were given the opportunity to learn by doing (e.g. conducting experiments, building models or products, taking measurements, conducting research, using project based learning...) | | | | |
| 29 | During the last year, the students were given the opportunity to teach or guide other students or the whole class or to present a subject or problem that they worked on it | | | | |

## APPENDIX B

## The Questionnaire in its Final Form

## Research Questionnaire

Dear teacher,

My name is Elias, and I am a doctoral student in the department of education at the Adam-Mickiewicz University in Poznań, Poland. I am currently conducting research about science teacher's perception of teaching-learning processes in the middle schools. Analyzing the research data will enable me to suggest ways to improve science teaching in school.

This questionnaire contains two parts, the first part relates to background variables, and the second part includes statements regarding beliefs and practices in the context of teaching science in the classroom. The questionnaire is anonymous and all data collected in this study will remain confidential and will be used for research purposes only.

Your cooperation is essential to present a credible image of the subject I am investigating. If you feel uncomfortable completing the questionnaire, you can stop filling. If you have questions or doubts about the questionnaire or the research, please call me on 0547373788.

I thank you in advance for your cooperation and your willingness to participate in the research.

The questionnaire is formulated in masculine form and is intended for both men and women. The estimated time to fill the questionnaire is 15-20 minutes.

Elias Abu Ghanima- the Researcher

### Personal and Professional Background Data-Part I

Please mark **X** in the appropriate box.

1. Gender: ☐ Male ☐ Female
2. Educational qualification: ☐ B.Sc. ☐ B.Ed. ☐ M.Sc. ☐ M.Ed. ☐ Ph.D. ☐ Other
3. Teaching experience: ☐ 1 to 5 years ☐ 6 to 10 years ☐ 11 to 15 years ☐ More than 15 years
4. School Type (sector): ☐ State ☐ Private

**Beliefs and Practice-Part II**

1. The items listed below are related to teaching and learning. Please indicate to what extent you agree or disagree with these items on the given scale: 1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree.

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Strongly disagree | Disagree | Agree | Strongly agree |
| 1 | Prior knowledge of students does not play an important role when they learn new topic | | | | |
| 2 | Students learn better when they know how the content can be applied in daily life | | | | |
| 3 | Sharing students in selecting what topics or activities to be learned, increases their involvement in the learning process | | | | |
| 4 | Teacher should explain explicitly to the students why it is worthy for them to learn a particular topic | | | | |
| 5 | Student learns better when the learning activity focused on students' interest is close to his/her life | | | | |
| 6 | Topics the students learn in classroom do not necessarily have to be related to the students' personal goals or future fields of work in which they are interested | | | | |
| 7 | Teacher is supposed to provide challenging tasks that are adapted to the learner's unique abilities, that lead him/her to success and excellence. | | | | |
| 8 | Students learn more effectively if they relate the material they learn to what they previously learned | | | | |
| 9 | Students can assess their understanding of a particular idea presented in the classroom, by rewriting and summarizing the idea in their own words | | | | |
| 10 | Students can succeed in learning a content whether if they use high-order thinking processes or not | | | | |
| 11 | Students learn best by finding solutions to problems themselves | | | | |

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Strongly disagree | Disagree | Agree | Strongly agree |
| 12 | Applying knowledge and skills learned in class in new contexts does not necessarily reflect student understanding | | | | |
| 13 | Students are supposed to accept any knowledge presented in the class without giving them an opportunity to present doubt on this knowledge | | | | |
| 14 | Teacher should allow students to give only one explanation or one solution to a problem | | | | |
| 15 | Students should accept any information received from any source without the need to assess its trustworthiness | | | | |
| 16 | Evidence gathered to support a particular claim should not be discussed whether it support the claim or not | | | | |
| 17 | It is sufficient to present the knowledge acquired by the students in one specific and unique way | | | | |
| 18 | Students are supposed to provide explanations and reasons why their point of view is the right one | | | | |
| 19 | Students are supposed to bring contradictory evidence to ideas presented by others | | | | |
| 20 | Students should draw and justify conclusions from the research work they did before the teacher did so | | | | |
| 21 | Learning becomes more effective when students assess personally their learning progress | | | | |
| 22 | Students will be more successful if they use feedback from self-assessment to make improvement in their learning performance | | | | |
| 23 | Assessment of students' learning outcomes should be based upon predefined criteria/rubrics | | | | |
| 24 | Feedback from ongoing assessment plays a problematic role in designing the learning activities | | | | |
| 25 | Assessment of students' understanding should be performed only in the end of teaching the unit | | | | |
| 26 | It is a waste of time to give detailed written feedback on students' work in addition to marking | | | | |

| | Item | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Strongly disagree | Disagree | Agree | Strongly agree |
| 27 | Learning becomes more effective when teacher provides immediate feedback during their work on a task | | | | |
| 28 | Learning a topic by doing (e.g. conducting experiments, building models or products, making measurements, conducting inquiry, project-based learning, etc.) leads to a better understanding of this topic | | | | |
| 29 | Student will learn more effectively in learning by doing, compared to learning by listening to a teacher's lecture | | | | |
| 30 | Learning by doing makes it more difficult for the student to learn the content | | | | |
| 31 | Having to work within learning by doing invest more time and efforts, compared to learning by listening to a teacher's lecture | | | | |
| 32 | Student who learns by doing will understand the material faster, compared to learning it by listening to a teacher's lecture | | | | |
| 33 | Student who learns new content by himself/herself in order to teach it to his/her classmates will better understand this content, compared to learning it by listening to a teacher's lecture | | | | |
| 34 | Student who learns new content by himself/herself in order to teach it to his/her classmates learns more effectively this content, compared to learning it by listening to a teacher's lecture | | | | |
| 35 | Student who learns new content by himself/herself in order to teach it to his/her classmates, makes it more difficult for him/her to learn the content | | | | |
| 36 | Student who learns new content by himself/herself in order to teach it to his/her classmates invest more time and efforts, compared to learning by listening to a teacher's lecture | | | | |
| 37 | Student who learns new content by himself/herself in order to teach it to his/her classmates, will understand the material faster, compared to learning it by listening to a teacher's lecture | | | | |

2. The following items indicate teaching and learning activities. Please carefully specify the frequency which each action is expressed in the lessons you actually teach in your class on the given scale: 1. Never 2. Occasionally 3. Frequently 4. Always.

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Never | Occasionally | Frequently | Always |
| 1 | A new subject learned in the classroom is based on prior knowledge that the student has | | | | |
| 2 | Students are given the opportunity to apply the knowledge or skills they have learned in the classroom in situations related to daily life or to real world outside the school | | | | |
| 3 | Students are given the opportunity to decide what topics they are going to learn and which learning activities they will do | | | | |
| 4 | I state explicitly why it is important to the students to learn a particular topic | | | | |
| 5 | I give a learning activity or a task, based on the students' personal interest | | | | |
| 6 | Students are given the opportunity to learn many things in the classroom that are suitable for their personal goals or future careers | | | | |
| 7 | Students are given various tasks and learning activities, adapted to their abilities and pace of learning | | | | |
| 8 | Students are given the opportunity to make connections between concepts they already know and concepts that will be learned in the future | | | | |
| 9 | Students are given the opportunity to rewrite or summarize the main ideas from books or other sources using their own words | | | | |
| 10 | Students are given the opportunity to apply higher order thinking processes when they learn a certain content | | | | |

| | Item | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Never | Occasionally | Frequently | Always |
| 11 | Students are given the opportunity to investigate real problems themselves and think of solutions to these problems before the teacher shows them how they are resolved | | | | |
| 12 | Students are given the opportunity to apply the knowledge and skills they have acquired in class to new problems and situations | | | | |
| 13 | Students are given the opportunity to doubt/ask about information, that is confusing them, for clarification | | | | |
| 14 | Students are given the opportunity to present ideas from different points of view, such as to present various options to solve a problem | | | | |
| 15 | Students are given the opportunity to evaluate the reliability of sources of information they used | | | | |
| 16 | Students are given the opportunity to judge if a given evidence supports a certain claim | | | | |
| 17 | Students are given the opportunity to interpret data in various ways such as: images, charts, graphs and tables | | | | |
| 18 | Students are given the opportunity to present arguments and provide reasons to justify them | | | | |
| 19 | Students are given the opportunity to give evidence that disconfirms other's ideas | | | | |
| 20 | Students are given the opportunity to draw and justify conclusions from a research work, in which they have participated | | | | |
| 21 | Students are given the opportunity to assess their own learning progress | | | | |
| 22 | Students use feedback based on self-assessment to promote and improve their learning | | | | |
| 23 | Assessment of students' learning outcomes is based upon predefined criteria/rubrics | | | | |

| Item | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Never | Occasionally | Frequently | Always |
| 24 | Learning activities are mainly shaped, based upon feedback from ongoing assessment processes | | | | |
| 25 | Students' understanding is assessed continuously during and in the end of the learning process | | | | |
| 26 | Students are given detailed written feedback on their work in addition to marking | | | | |
| 27 | When students perform a task they receive immediate feedback from a teacher | | | | |
| 28 | During the last year the students were given the opportunity to learn by doing (e.g. conducting experiments, building models or products, taking measurements, conducting research, using project based learning...) | | | | |
| 29 | During the last year the students were given the opportunity to teach or guide other students or the whole class or to present a subject or problem that they learned themselves | | | | |

## APPENDIX C

### Teachers' Interview

My name is Elias Abu-Ghanima, and I am a doctoral student in the department of education at the Adam-Mickiewicz University in Poznań, Poland. I am currently conducting a research project that aims to identify obstacles and conditions that may improve a new approach to students' learning, for instance meaningful learning in Arab middle school in Israel. The knowledge that will be gained in this research can be used to improve future expanding reform and efforts to promote meaningful learning in science education. I would like to ask you some questions regarding this issue based on your experience in teaching science.

I hope to use the information, that you are going to contribute through this interview, to address the following research questions:

- What conditions should be provided to enhance meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion?
- What obstacles do science teachers face in implementing the meaningful learning in science teaching in Arab middle schools in northern Israel, according to science teachers' opinion?

I will maintain confidentiality of all data that will be collected. There will be no personally identifiable information about any of the project participants. The interview should take about 45 minutes.

### Personal and Professional Background Data

Please mark **X** in the appropriate box.

5. Gender: ☐ Male ☐ Female
6. Age: ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50+
7. Educational qualification: ☐B.Sc. ☐ B.Ed. ☐ M.Sc. ☐M.Ed. ☐Ph.D. ☐Other
8. Teaching experience: ☐ 1 to 5 years ☐6 to 10 years
   ☐ 11 to 15 years ☐ More than 15 years
9. School Type (sector): ☐ State ☐ Private

## The Interview Open-ended Questions

1. In your opinion, what kind of pedagogical conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?
2. In your opinion, what kind of administrative conditions could improve implementing of meaningful learning in science teaching in Arab middle schools?
3. In your opinion, what kind of conditions related to students could improve implementing of meaningful learning in science teaching in Arab middle schools?
4. In your opinion, what obstacles do science teachers face in implementing the meaningful learning in science teaching in Arab middle schools?

## APPENDIX D

### References of the Beliefs and Practice Sections of the Questionnaire

| Item # | Category | Items in the Beliefs Section | Items in the Practice Section | Reference |
|---|---|---|---|---|
| **Relevance** | | | | |
| 1 | Prior Knowledge | Prior knowledge of students does not play an important role when they learn new topic | A new subject learned in the classroom is based on prior knowledge that the student has | (Ausubel, 1968), (Keller, 1983), (Bransford et. al., 2000), (Shulman, 2014), (Hattie, 2012) |
| 2 | Real Life Experience | Students learn better when they know how the content can be applied in daily life | Students are given the opportunity to apply the knowledge or skills they have learned in the classroom in situations related to daily life or to real world outside the school | (Stuckey et al., 2013), (Keller, 1983), (Century Curriculum and Instruction, 2007) |
| 3 | Choice | Sharing students in selecting what topics or activities to be learned, increases their involvement in the learning process | Students are given the opportunity to decide what topics they are going to learn and which learning activities they will do | (Keller, 1983), (Patall et al., 2010) |
| 4 | Present Worth | Teacher should explain explicitly to the students why it is worthy for them to learn a particular topic | I state explicitly why it is important to the students to learn a particular topic | (Briggs, 2014), (Mayer, 2002), (Earl, 2013) |
| 5 | Interests | Student learns better when the learning activity focused on students' interest is close to his/her life | I give a learning activity or a task, based on the students' personal interest | Stuckey et al. (2013), (Eccles et al.'s, 1983), (Steven, 2014) |
| 6 | Future Goals | Topics the students learn in classroom do not necessarily have to be related to the students' personal goals or future fields of work in which they are interested | Students are given the opportunity to learn many things in the classroom that are suitable for their personal goals or future careers | (Keller, 1983), (Eccles et al.'s, 1983), (Briggs, 2014) |

| Item # | Category | Items in the Beliefs Section | Items in the Practice Section | Reference |
|---|---|---|---|---|
| 7 | Cognitive ability | Teacher is supposed to provide challenging tasks that are adapted to the learner's unique abilities, that lead him/her to success and excellence | Students are given various tasks and learning activities adapted to their abilities and pace of learning | |

**Knowledge construction**

| Item # | Items in the Beliefs Section | Items in the Practice Section | Reference |
|---|---|---|---|
| 8 | Students learn more effectively if they relate the material they learn to what they previously learned | Students are given the opportunity to make connections between concepts they already know and concepts that will be learned in the future | (Michael & Modell, 2003), (Forbes et al., 2001), (Hammond, 1992) |
| 9 | Students can assess their understanding of a particular idea presented in the classroom, by rewriting and summarizing the idea in their own words | Students are given the opportunity to rewrite or summarize the main ideas from books or other sources using their own words | |
| 10 | Students can succeed in learning a content whether if they use high-order thinking processes or not | Students are given the opportunity to apply higher order thinking processes when they learn a certain content | (Zhu, 2006) |
| 11 | Students learn best by finding solutions to problems themselves | Students are given the opportunity to investigate real problems themselves and think of solutions to these problems before the teacher shows them how they are resolved | (Michael & Modell, 2003) |
| 12 | Applying knowledge and skills learned in class in new contexts does not necessarily reflect student understanding | Students are given the opportunity to apply the knowledge and skills they have acquired in class to new problems and situations | (Mayer, 2002) |

| Critical thinking | | | |
|---|---|---|---|
| Item # | Items in the Beliefs Section | Items in the Practice Section | Reference |
| 13 | Students are supposed to accept any knowledge presented in the class without giving them an opportunity to present doubt on this knowledge | Students are given the opportunity to doubt/ask about information, that is confusing them, for clarification | (Ennis, 1985), (Brookfield 1987) |
| 14 | Teacher should allow students to give only one explanation or one solution to a problem | Students are given the opportunity to present ideas from different points of view, such as to present various options to solve a problem | (Ennis, 1985) |
| 15 | Students should accept any information received from any source without the need to assess its trustworthiness | Students are given the opportunity to evaluate the reliability of sources of information they used | (Brookfield 1987) |
| 16 | Evidence gathered to support a particular claim should not be discussed whether it support the claim or not | Students are given the opportunity to judge if a given evidence supports a certain claim | (Ennis, 1985) (Facione, 1990) |
| 17 | It is sufficient to present the knowledge acquired by the students in one specific and unique way | Students are given the opportunity to interpret data in various ways such as: images, charts, graphs and tables | (Ennis, 1985) |
| 18 | Students are supposed to provide explanations and reasons why their point of view is the right one | Students are given the opportunity to present arguments and provide reasons to justify them | (Halpern, 1998) |
| 19 | Students are supposed to bring contradictory evidence to ideas presented by others | Students are given the opportunity to give evidence that disconfirms other's ideas | (Willingham, 2007). |
| 20 | Students should draw and justify conclusions from the research work they did before the teacher did so | Students are given the opportunity to draw and justify conclusions from a research work, in which they have participated | (McPeck, 1990) |

| **Feedback** | | | |
|---|---|---|---|
| Item # | Items in the Beliefs Section | Items in the Practice Section | Reference |
| 21 | Learning becomes more effective when students assess personally their learning progress | Students are given the opportunity to assess their own learning progress | (Earl, 2013) |
| 22 | Students will be more successful if they use feedback from self-assessment to make improvement in their learning performance | Students use feedback based on self-assessment to promote and improve their learning | (Black & Wiliam, 1998), (Harlen, 2006) |
| 23 | Assessment of students' learning outcomes should be based upon predefined criteria/rubrics | Assessment of students' learning outcomes is based upon predefined criteria/rubrics | (Barron & Hammond, 2008), |
| 24 | Feedback from ongoing assessment plays a problematic role in designing the learning activities | Learning activities are mainly shaped, based upon feedback from ongoing assessment processes | (Earl, 2013) |
| 25 | Assessment of students' understanding should be performed only in the end of teaching the unit | Students' understanding is assessed continuously during and in the end of the learning process | (OECD, 2008*b*) |
| 26 | It is a waste of time to give detailed written feedback on students' work in addition to marking | Students are given detailed written feedback on their work in addition to marking | |
| 27 | Learning becomes more effective when teacher provides immediate feedback during their work on a task | When students perform a task they receive immediate feedback from a teacher | |

| Learning by doing | | | |
|---|---|---|---|
| Item # | Items in the Beliefs Section | Items in the Practice Section | Reference |
| 28 | Learning a topic by doing (e.g. conducting experiments, building models or products, making measurements, conducting inquiry, project-based learning, etc.) leads to a better understanding of this topic | During the last year the students were given the opportunity to learn by doing (e.g. conducting experiments, building models or products, taking measurements, conducting research, using project based learning...) | |
| 29 | Student will learn more effectively in learning by doing, compared to learning by listening to a teacher's lecture | During the last year the students were given the opportunity to teach or guide other students or the whole class or to present a subject or problem that they learned themselves | |
| 30 | Learning by doing makes it more difficult for the student to learn the content | | |
| 31 | Having to work within learning by doing invest more time and efforts, compared to learning by listening to a teacher's lecture | | |
| 32 | Student who learns by doing will understand the material faster, compared to learning it by listening to a teacher's lecture | | |

| Learning based on teaching | | | |
|---|---|---|---|
| Item # | Items in the Beliefs Section | Items in the Practice Section | Reference |
| 33 | Student who learns new content by himself/herself in order to teach it to his/her classmates will better understand this content, compared to learning it by listening to a teacher's lecture | During the last year the students were given the opportunity to teach or guide other students or the whole class or to present a subject or problem that he or she worked on it | |
| 34 | Student who learns new content by himself/herself in order to teach it to his/her classmates learns more effectively this content, compared to learning it by listening to a teacher's lecture | | |
| 35 | Student who learns new content by himself/herself in order to teach it to his/her classmates, makes it more difficult for him/her to learn the content | | |
| 36 | Student who learns new content by himself/herself in order to teach it to his/her classmates invest more time and efforts, compared to learning by listening to a teacher's lecture | | |
| 37 | Student who learns new content by himself/herself in order to teach it to his/her classmates, will understand the material faster, compared to learning it by listening to a teacher's lecture | | |

## APPENDIX E

## Preliminary Pilot Research- Interview

My name is Elias Abu-Ghaneema, and I am conducting a research project that aims to identify perceptions, beliefs and practices in science teaching in middle schools that may improve students' understanding and learning. I would like to give you two assignments and some questions about your experience in teaching science in your class.

I will maintain confidentiality of all data collected. There will be no personal information about project participants. If you feel discomfort you can stop the interview. The interview should take about 45 minutes.

Thanks you

The two interview assignments and their guiding questions were as follow:

**A. Describe one science lesson, you remember as the best lesson you taught. (for identifying actual practices in science teaching)**

1. Why did this lesson become the best lesson?
2. What is the dominant factor/element that makes this lesson the best?
3. What did you do for making this lesson the best?
4. What did learners do for making this lesson the best?
5. Describe what impressions did learners show in this lesson.
6. What were the main considerations that you took in planning this lesson?
7. Did the learning material play a role in making this lesson become the best? Explain how.
8. What instructional strategies/methods did you use in that lesson?
9. What were the main features of the learning environment in this lesson?
10. What was the most important element you focused on when you were planning this lesson?
11. How were the learners organized during the lesson?
12. How did you assess or reflect learners' understanding of the learning material during this lesson?
13. What thinking skills did you try to develop in this lesson?

**B. Describe your philosophy about science teaching in practice in your lessons. (for identifying general beliefs and practices in science teaching)**

1. What are the aims of teaching science according to your opinion?
2. What instructional strategies do you use in teaching science?
3. What should you do to make the learning activity in science the best?
4. What should learners do in the lesson to make the learning activity the best?
5. What are the main features the learners should have in order to understand the material?
6. What are the goals of assessment that you use in teaching science?
7. What assessment methods do you use in teaching science?
8. What should you do to make the learning material more meaningful to the learner?
9. What is the first step that you should do in teaching a new topic?
10. What kind of thinking skills do you focus on to develop in your lessons?
11. How can you make your learners be more responsible for their learning?
12. What should you do to explain to the learners why and what they should learn the new topic?
13. What do you do to motivate the learners to participate in the learning activity?
14. Can you identify the strongest motivator for the students' learning?
15. How can you help the students to achieve deep understanding of the new material?
16. How do you examine the learners' understanding of the material learned during the lesson or how learners demonstrate their understanding?
17. What are the main considerations you take in lesson planning?