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MEANINGFUL LEARNING: THE MAIN CONSTITUTIVE AND CONSECUTIVE COMPONENTS AND THEIR PRESENCE IN SCIENCE TEACHING

INTRODUCTION

The rapidly changing society of 21st century means that we ought to prepare our students for such a cultural dynamic[1]. Instead of focusing on memorizing facts, education is rather be targeted towards the development of meaningful understanding by engaging learners in the process of meaning construction and developing the ability to transfer knowledge to new situations. Meaningful learning has been proposed as an approach for learning with understanding[2]. Johannsen et al.[3] describes meaningful learning as an active process whereby newly acquired knowledge is interpreted against prior knowledge, thus fostering greater and deeper understanding.

David Ausubel[4] states that meaningful learning takes place when new concepts and propositions are integrated in a hierarchically arranged framework in cognitive structure. Since 2013, there have been considerable efforts in the Israeli educational system to widely promote the national program of „Meaningful learning" among all educational institutions[5] The scientific and technological

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[1] J. McTighe, E. Seif, *Teaching for Understanding: A Meaningful Education for 21st Century Learners*, „Teachers Matter" 2014, vol. 2, p.15–17.

[2] J.A. Michael, *In Pursuit of Meaningful Learning*, „Advances in Physiology Education" 2001, no. 26, p.72–84.

[3] A. Johannsen, K. Bolander-Laksov, N. Bjurshammar, B. Nordgren, C. Fridén, M. Hagströmer, *Enhancing meaningful learning and self-efficacy through collaboration between dental hygienist and physiotherapist students - a scholarship project*, „International Journal of Dental Hygiene" 2012, no. 10(4), p. 270–276.

[4] D. Ausubel, *The Psychology of Meaningful Verbal Learning*, Grune and Stratton, New York 1963.

[5] *Policy for Promoting Meaningful Learning in the Educational System*, Ministry of Education, Israel, Jerusalem 2013.

education is perceived as necessary for providing knowledge and skills that are preliminary for every student that will eventually become an adult citizen of the 21st century[6]. So far, there exists no published evaluation of the perceptions and practices of science teaching with respect to meaningful learning in the Arab educational system. Therefore, the purpose of this study is to identify the presence of perceptions and practices in science teaching, which are in line with the components of meaningful learning as demonstrated by science teachers at the Israeli Arab schools in the Galilee.

MEANINGFUL LEARNING COMPONENTS

Novak and Canus[7] define meaningful learning as the underlying theme of constructivism that integrates cognitive, affective, and psychomotor aspects. Constructivism is a theory of learning or meaning-construction that offers an explanation of the nature of knowledge and how human beings learn. It argues that people create or construct their new understandings or knowledge through an interaction of what they already know and believe in terms of concepts and ideas with what they come in contact with[8].

To achieve the aims of this study, identifying perceptions and practices in science teaching will be based on the constructivist theory as the theoretical framework of meaningful learning. Based on an analysis of teachers' descriptions, there emerges two components for meaningful learning, which are: the constitutive and the consecutive one. Six categories of meaningful learning to emerge from the analysis were divided across these two components as described below.

The constitutive component describes the core features relevant to the student that are crucial for meaningful learning. These features are further explained in more detail.

Authenticity: Herod describes authentic learning as a process in which "materials and activities are framed around 'real life' contexts in which they would be used"[9]. The Partnership for 21st Century Skills[10] 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".

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[6] R. Goldschmidt, *Science and Technology Education*, Research and Information Center of the Knesset–Israel, Jerusalem 2010.

[7] J. Novak, A. Canus, *Learning, Creating, and Using Knowledge: Concept Maps as facilitative tools in Schools and Corporation*, Lawrence Erlbaum Associates, Mahwah, NJ 1998.

[8] V. Richardson, *Constructivist teacher education*, Falmer Press, London 1997.

[9] L. Herod, *Adult learning from theory to practice*, 2002, http://jarche.com/wp-content/uploads/2015/12/adult_learning.pdf.

[10] *Century Curriculum and Instruction*, Partnership for 21st Century Skills, Washington DC 2007.

Prior knowledge: Determining students' prior knowledge has been recognized as an important factor in science teaching and an essential part of developing teaching strategies[11]. Ausubel (1968)[12] emphasizes the importance of prior knowledge in the learning process, claiming that „The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly". Meaningful learning occurs as students consciously and explicitly connect their new knowledge to existing knowledge structure[13].

The consecutive component describes the pedagogical activities that should be addressed by the teacher to engage students in meaningful learning. A more detailed explanation of the consecutive component will be further discussed.

Knowledge construction: Constructing knowledge is important for students' learning because it ensures that students are experiencing meaningful learning. At the knowledge construction level, students express thoughts that include justification, arguments or decision making[14].

Ausubel et al. (1978)[15] used the term 'meaningful' to describe the interaction between new knowledge and previously existing one. This interaction constitutes the 'knowledge construction process' that is one of the fundamental principles of constructivism**.**

*Cooperative learning***:** According to literature, effective teaching in science is achieved by encouraging students to work or co-operate with each other in constructing their own understanding[16]. Learners do not construct knowledge in isolation but through social interaction with their classmates and as such the interactions among learners affect each other's learning[17]. Working with other students is a critical component of the process of knowledge construction. Peer-peer discussions in co-operative learning groups can promote meaningful learning enabling learners to help each other incorporate new experiences and information

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[11] J.D. Novak, D.B. Gowin, *Learning How to Learn*, Cambridge University Press, Cambridge 1984.

[12] D. Ausubel, *Educational Psychology: A Cognitive View*, Holt, Rinehart & Winston, New York 1968.

[13] J. Mintzes, J. Wandersee, J. Novak, *Teaching science for understanding*, Academic Press, San Diego CA 1998, p. 328–350.

[14] C. McLoughlin, J. Luca, *Cognitive Engagement and Higher Order Thinking Through Computer Conferencing: We Know Why but Do We Know How*? [in:] *Flexible Futures in Tertiary Teaching. Proceedings of The 9th Annual Teaching Learning Forum*, ed. A. Herrmann, M.M. Kulski, Curtin University of Technology, Australia, Perth 2000, p. 1–10.

[15] D.P. Ausubel, J.D. Novak, H. Hanesian, *Educational Psychology: A Cognitive View*, Holt, Rinehart & Winston, New York 1978.

[16] J. Munro, *Learning More About Learning Improves Teacher Effectiveness*, „School Effectiveness and School Improvement" 1999, no. 10(2), p. 151–171.

[17] L.S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, Harvard University Press, Cambridge MA 1978.

into their existing cognitive structures[18]. Therefore, it is believed that co-operative learning can cultivate the development of deep understanding[19].

Feedback from ongoing formative assessment: Teachers need to continuously monitor and evaluate students' understanding[20] in order to identify and correct students' misconceptions at an early stage before they become too deeply rooted. The process of evaluating students' work or performance and using the information obtained from these practices to modify teachers' and students' work for the purposes of optimizing teaching and learning is known as formative assessment[21].

Formative assessment in the form of continuous feedback is especially beneficial for clarifying learning goals, ensuring continuous monitoring, responding to learners' progress, encouraging adaptation and improvements in learning outcomes and involving students in meaningful self and peer assessment[22].

Learning by doing means learning from experience resulting directly from one's own actions[23]. Learning by doing invites a direct and tangible encounter of the learners with the components of the experiment: conducting experiments and observations, operating instruments, analysis and construction of products[24]. Greenberg (2014)[25] points out to the importance of physical activity to normal brain development including the ability to solve complex problems, process information, activate memory and improve concentration as well as attention.

RESEARCH METHOD

A qualitative descriptive methodological approach was employed in this study to identify perceptions and practices that are consistent with meaningful learning in science teaching. The descriptions were categorized based on the theoretical constructivist model.

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18 J. Mintzes et al, *Teaching science...*, op. cit., p. 60–90.

19 B. Joyce, M. Weil, E. Calhoun, *Models of Teaching*, Allyn and Bacon, Boston 2000.

20 R. Hipkins, R. Bolstad, R. Baker, A. Jones, M. Barker, B. Bell, R. Coll, B. Cooper, M. Forret, B. France, M. Haigh, A. Harlow, I. Taylor, *Curriculum, Learning and Effective Pedagogy: A Literature Review in Science Education*, Ministry of Education, Wellington 2002.

21 P. Black, D. Wiliam, *Inside the Black Box: Raising Standards through Classroom Assessment*, „Phi Delta Kappan" 1978, no. 80(2), p. 139–144.

22 J. Pellegrino, M. Hilton, *Education for life and work*, The National Academies Press, Washington D.C. 2012.

23 H. Reese, *The learning-by-doing principle*, „Behavioral Development Bulletin" 2011, no. 17(1), p. 1–19.

24 *Cite a Website - Cite This for Me* 2017, http://meyda.education.gov.il/files/Tochniyot_Limudim/Mada/ekronot.doc [Accessed: 13.07.2017].

25 Ahronoth Y., *Active children, smart children*, Jerusalem 2014.

RESEARCH SAMPLE

The research method was applied to a sample of six science teachers, who work at a full-time job at various Arab schools in the Galilee. The choice of teachers for the sample is based on considerations of their teaching seniority (above ten years) and rich experience in teaching science.

RESEARCH INSTRUMENT

The study method consists of semi-structured interviews of science teachers. The interviews were formed based on two assignments 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 in teaching science’. These assignments were aimed at identifying perceptions, beliefs and practices in science teaching. The descriptions obtained from the interviews were collected based on sub-questions focusing on specific points regarding teaching-learning processes in science. The data collected from the interviews was documented.

PROCEDURE

Six teachers were first contacted by the phone and shared with the research significance and objectives for the sake of obtaining their collaboration. Following the conversation, the researcher appointed an interview. The descriptions were automatically documented at the time the interview has taken place in Arabic and were later translated into English and revised by a professional editor.

DATA ANALYSIS

Data were analyzed based on constructivist framework by deductive approach. The selected categories of this framework reflect the collected data. In line with the inductive approach, meanings and connections between ideas identified to develop other categories.

RESULTS AND DISCUSSION

Table 1 presents the two sets of meaningful learning components. Six categories have been concluded from interviews with science teachers regarding the two assignments.

Table 1. Overview of Meaningful Learning Components and Categories

Components	Categories
Constitutive	*Prior knowledge*
	Authenticity
Consecutive	*Knowledge Construction*
	Feedback
	Learning by Doing
	Cooperative Learning

RESULT AND DISCUSSION OF THE FIRST ASSIGNMENT

The first assignment was aimed at identifying classroom *practices* in science teaching which are in line with meaningful learning within the constructivist approach. Six categories of practices have been recognized from the descriptions: authenticity, prior knowledge, knowledge construction, cooperative learning, learning by doing, and feedback.

Regarding the constitutive component, the results can be divided into two categories: 'authenticity' and 'prior knowledge'. As for the consecutive component, the results point to four categories: 'cooperative learning', 'knowledge construction', 'learning by doing', and 'feedback'.

An example shows how 'authenticity' is integrated in the science lessons: *"We have discussed the new law which demands that every consumer must pay for the plastic bag, which is used to fill purchases" (Sh2).* In this regard, supporting the importance of this category in students' learning, the partnership for 21st century skills[26] states: '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'**.**

The following example shows how 'prior knowledge' comes into expression in science lessons: *"Before we began the learning activity we used sun associations, discussions and questions to reveal what students know about the topic" (L).* In this respect, determining students' prior knowledge has been recognized as an important factor in science teaching and an essential part of developing teaching strategies[27], because meaningful learning occurs as students consciously and explicitly connect their new knowledge to prior knowledge structure[28].

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26 *Century Curriculum and Instruction...*, op. cit.

27 J.D. Novak, D.B. Gowin, *Learning How to Learn...*, op. cit..

28 J. Mintzes, J. Wandersee, J. Novak, *Teaching science...*, op. cit., p. 328–350.

An additional example also shows how 'knowledge construction' is integrated in science lessons: *„After the students carry out the experiment, they are given the opportunity to ask questions about the experience, they explain and analyze the results and draw conclusion" (S1)*. Supporting this by Howland et. al. who claims that learners begin constructing their own simple mental models, which consist of organized connected pieces of knowledge, when they explain what they observe through experience[29].

'Cooperative learning' is another category of the consecutive component. One example taken from the descriptions is: *"Students worked in small heterogeneous groups to learn about the periodic table. They were asked to classify cards of element symbols based on their characteristics and then to build a model of periodic table in many shapes. All the students were active and they cooperated in the work. Each student tried to explain to his peers about his work" (S2).* It is believed that cooperative learning can cultivate the development of deep understanding[30]. Learners construct knowledge through social interaction with their classmates and thus, the interactions among learners affect each other's learning[31].

'Learning by doing' involves students in a physical as well as mental activity. An example described by teachers is: *"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" (Sh1).* Greenberg (2014)[32] points out to the importance of physical activity to normal brain development and improved management skills, including the ability to solve complex problems, process information, activate memory, enhance concentration and attention. The following example shows how *feedback based* on an ongoing formative assessment is shown 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. I tried to adapt my students to the teaching-learning method" (Sh2)*. Supporting this idea, Hipkins et al.[33] suggested that teachers need to continuously monitor and evaluate students' understanding in order to identify and correct students' mistakes at an early stage before they become too deeply embedded. It can be inferred from teachers' views, that a good and effective lesson is characterized with components consistent with meaningful learning. This

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29 J.L. Howland, D.H. Jonassen, R.M. Marra, *Meaningful Learning with Technology* (4-th edition), Pearson, Boston 2012.
30 B. Joyce et al., *Models of Teaching*..., op. cit.
31 L.S. Vygotsky, *Mind in Society*..., op. cit.
32 Y. Ahronoth, *Active children, smart children*, Jerusalem 2014.
33 R. Hipkins et al, *Curriculum, Learning and Effective Pedagogy*..., op. cit.

emphasizes the importance of meaningful learning as a main educational goal, which needs to be further expanded and implemented in the educational system at schools.

RESULT AND DISCUSSION OF THE SECOND ASSIGNMENT

The second assignment was aimed at identifying *perceptions and beliefs* which have an implication on promoting meaningful learning in science teaching. Regarding the constitutive component, the results can be classified into two categories: 'authenticity' and 'prior knowledge', whereas for the consecutive component, the results can be classified into two categories: 'knowledge construction' and 'feedback'.

An example shows how 'prior knowledge' is perceived by science teachers: "*One of the considerations that the teacher should take into account when planning a lesson is to determine the student's prior knowledge and ideas regarding the new topic"*. 'authenticity' component expressed through this example is that *"It is important that parents participate in the teaching-learning process. There are many parents who participate in the construction of workshops according to their profession and the subject learned by students"*. The following example shows how 'feedback' is perceived by science teachers: *„The teacher should examine students' understanding of the learning material by using several methods including: asking oral questions during the lesson, continuous assessment, summarizing what the student understands in his words*. 'Knowledge construction' is described in the following example: *"students should be given the opportunity to be exposed to different teaching methods and facilities, such as: computer, experiments, simulation and games. This is necessary to develop higher skills, such as linking information with other topics, building arguments, drawing conclusions, asking questions, analyzing data, constructing hypotheses and examining them"*.

Based on these results, it can be concluded that the development of science teaching has led to a positive change in the perception of science and teachers implementation of pedagogical processes for promoting meaningful learning in the classroom.

SUMMERY AND RECOMMENDATIONS

This pilot study aimed at gathering information from science teachers concerning their perceptions, beliefs and practices in science teaching. The results show that teachers' perceptions and practices are consistent with some components of meaningful learning. Science teachers' descriptions led to the identification of six components: 'authenticity', 'prior knowledge', 'cooperative learning', 'knowledge construction', 'learning by doing', and 'feedback'.

Some recommendations are needed to develop and expand this study. First, there is a need to repeat the research on a larger scale, collecting descriptions from more science teachers pointing to other components of the constructivist approach that have not been included in this study. Second, future quantitative research is needed to measure the extent to which these components and others are practiced in classrooms and are consistent with teachers' perceptions and beliefs. The conclusions to be drawn from such a research can be used to improve and reform science education, more particularly in the Israeli Arab educational system.

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Summary

This pilot study aims to identify the presence of components which are consistent with meaningful learning in science teaching. Semi-structured interviews were conducted with six science teachers and the results show that some of the teachers' perceptions and practices in science teaching are consistent with meaningful learning components. Science teachers' descriptions led to the identification of six categories which can be classified into two sets of components: Constitutive (e.g., 'authenticity' and 'prior knowledge') and. Consecutive (e.g., 'cooperative learning', 'knowledge construction', 'learning by doing' and 'feedback'). Based on these results, it can be concluded that there is a positive change in teachers' perceptions and implementation of pedagogical processes for promoting meaningful learning in science teaching. The implications of these findings for future research are discussed.