# Restructuring 19th Century Students' Idea in Positivist Curriculum Using Drawings' Analogies

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**Abstract**

Four students' teachers in Master Science program were subjected to instruction that aimed to master the suitable strategies in changing misconceptions. The most active and verbal student in the class had been subjected to autobiographic case study; he had been asked to write a journal including the followings: A. The most complicated idea, he believed to work as a critical barrier in understanding revolutionary type of science. B. The reason for such misunderstanding and C. The teaching strategy, he believed, to help in making successful restructuring to his concept. Student' journal shows the followings: A. The existence of empty space between particles - moving in all directions-was the most complicated idea to be difficult to grasp; there was misunderstanding that changing in atmospheric pressure by changing latitude is due to the change in the accumulated continuous air forces that are implied on the square centimeter of flexible wall (football in this case). B. It had been indicated that such misunderstanding, on behalf of students, was due to the fact that 19th century positivists assumptions about nature of matter (that had been adapted by science educators), had led to establish instruction on discovery methods to prove those historical ideas. C. It had been pointed out that using analogies' drawings rather than videos, to distinguish between alternative ideas and the scientific ones had helped in restructuring erroneous ideas. D. It had been pointed out that presenting a comprehensive view that takes into account all factors to explain a given phenomena, in which the pressure concept is linked to the gravity, and the atmospheric components theme, is of great importance in restructuring ideas

**Keywords:** case study, atmospheric pressure, positivist curriculum, misconceptions, drawings' analogies

## Introduction

Shepardson and Pizzini (1991) indicated that; regardless of discipline, science textbooks emphasize input-level questions which lead to establisha low level cognitive purpose. In the same way, Kortland (1996) showed that even after instruction, that aimed to restructure students' misconception, students remained to have a limited scope with respect to complex theories.

These problems that had been pointed out regarding learning and teaching scientific concepts, in the nineties, still sustains itself in 21th century. Science educators paid their attention in the last two decades to the fact that instruction per se is not sufficient to overcome difficulties students face in understanding science.

Lieto, A.,Damiano, R., and Michielon, V., 1996 proposed that formal ontology could be employed to describe and document cultural heritage with twofold goals; providing explicit and shared conceptual models of cultural heritage, and making documentation directly available in self-explanatory format. Mckenna, S., 2004 called for a new paradigm regarding curriculum design. Kincheloe, J. 2005, proposed that the solution for incommutability between the instruction and the outcome could be in teachers becoming self-directed professionals and curriculum developers. Pocovi' (2001), shows that students' alternative conceptions about revolutionary type of science are characterized by having a high degree of coherency; this gives a strong evidence for the need of instructional strategies to be accompanied by curriculum development. Kiraly, D., 2015, stated that constructivist approach is not sufficient to overcome students' difficulties in understanding science, he called for a wholeness view of learning process that goes beyond learner self experience into a post-positivist curriculum development model. Kilickaya, B., argued that positivism does not leave any reason for human independent learning.

The first science educator to point out the importance of epistemology in guiding curriculum development in science education was Schwab. Schwab, 1964, considered that students should understand the conceptual structure and the mode of investigation that led to conceptual innovation and not the discovery per se. He did not consider that students can discover great ideas that had gone through a lot of restructuring, simply, through discovery; he rather considered that the only way, is to get students realize that great ideas had gone through a lot of re-structuring in the history of science. Schwab (64, p 42) stated that "it is virtually impossible to provide step-by step description of innovation method; the detection of inadequeincie in current structure is an act of creative insight that students would not be able to recognize by simple method of discovery. The revision of a structure or the invention of a new one, is an act of creative imagination for which that could not be imitated to the school lab".

In the same way; Shulman &Tamir,1973, indicates that science teachers should not ask students at elementary stage to explain their findings, if they lack the essential background at that stage, merely letting students go through discovery method would push them to adapt historical science ideas, thinking that such idea is a stable one. Strike & Posner (1992) pointed out that conceptual change theory should identify the kinds of evidence needed for the restructuring of a major (paradigmatic) concept. Carey, 1984, Novak, and Gowin, 1986, considered that the process of induction would allow only the acceptance of theory, such process would not allow the refutation of stable students' concepts, and forming a more advanced ones. Students should identify the different restructuring structures that scientific concepts passed through; this would be of great help to make similar restructuring on the part of students. Zaid, 1988, pointed out,that in order to prevent recycling historical ideas in science, students should be aware of their historical origin. This process would allow the distinguishing of alternative views in historical revolutionary type of science, and the current ones.

The subject matter domain has also has to be taken into account during curriculum development: El-kilani and Zuibi, 2014 show that the strategy of restructuring, varies according the domain of subject matter; it had been found that the strategy of refutation students' naïve ideas and letting them aware of the scientific ones, through engaging in Socratic dialogue, was the most suitable strategy for teaching mechanics; however, presenting scientific concept in systematic narrative way, is the most suitable strategy for teaching biological concepts; while using concrete analogies to represent the particulate model of matter was the most suitable strategy to teach physical chemistry subject matter. In the same way, Newby, T.,&Stepich, D.,1987 called for using analogies as a meditational strategy to teach abstract concepts; El-Kilani, S, Doulat, A., & Al-Wraikat, M., 2012, asked for transferring students' ideas by using macroscopic particulate analogy mode; such strategy shows a good impact on changing students understanding regarding the particulate nature of matter. Jacobson & Archodidou, 2000, considered that designing visual –rich learning environment that includes imagistic simulations had a good impact in allowing forming mental images, visible thinking and explicit concrete structure of knowledge about scientific phenomena.

**Methodology**: This study investigates the conceptual understanding graduate students' teachers have, concerning foundational domains of scientific knowledge, and the appropriate instructional strategy to develop an accurate conceptual understanding in science. Specifically, the study was trying to understand the three factors affecting understanding of scientific concepts: a-the nature of scientific misconception that work as a critical barrier to understand scientific subject matter; b- the reason behind such stable misconception; and c- the best instructional strategy to overcome misconceptions.

Four teachers' students enrolled in methodology class as part of their fulfillment their Master degree in science education. The instruction aimed to master the best strategies in changing students' misconceptions in various domains of science subject matters. The method depends on linking and reducing wide range of scientific phenomena, using history of science in guiding the election of the revolutionary type of knowledge, let students aware of their misconceptions regarding them; and then, present the correct scientific idea in a hierarchical way; using dialectics Socratic dialogue regarding mechanic ideas; concrete analogy regarding particulate model of matter; and linear narrative comprehensive discussion, regarding biological concepts; hand drawing was used to make scientific ideas more explicit to students (Zaid &Zuibi 2014).

Autobiographical research methods had been used to investigate and describe participants' conceptual understanding over time. The most active and verbal student in the class had been elected and asked to write an essay journal about his feelings after instructions which include the followings:

A- The most complicated idea, he believed, to work as a critical barrier to understand revolutionary type of science.

B- The reason for such misunderstanding to complicated ideas in science.

C- The best instructional method, he believed, to help in making successful restructuring for his misconceptions.

**Findings and Analysis**: Student' autobiographic journal shows the followings:

A. Atmospheric pressure and the existence of empty space between particles was the most complicated concept that had been difficult to grasp. The student' journal refers to the one of the questions that was addressed to students during the class to uncover students' beliefs: A child at Amman hills intended to go for a journey to Ajloun hills. He pumped his football until became hard. In the way, his family stopped at Zarqa Valley, the child took his football to play with; he found his football became less harder, that it was difficult to play with; he suspected that there was a leakage in the football; when he reached his descent at Ajloun hills, he fetched his football to pump it again; he found, to his surprise, that his football felt hard again. Explain what happened by drawings:

The teacher student explain in his Journal that "there was a deep belief, before instruction, that air pressure defines a column of accumulated constant pushing forces that is exerted on the football wall, and that the changing of atmospheric pressure by changing latitude is due to the change in the accumulated air pressure forces that are implied on the square centimeter of flexible wall (football in the question addressed); such believing implies that Air particles are adjacent to each other; there are no spaces between particles" (The first figure in Appendix). After instruction, the journal of the participant, explained the reason for the decreasing in football hardness in the valley, in comparison, to that in the hills: "As the football was pumped up at the hill, the average separation of the molecules inside the football decreases, as the number of air molecules inside the football increases, the collision rate of air particles within the football wall increases; as the collision rate of air particles within the walls of the football increases, the pressure/hardness of the football increases; the pumping continue until the hardness of the football reach its maximum, here the number of air particles exerts their bombardment forces outside football walls equals to the number of particles exerts their bombardment forces within football walls. However, in the valley, the number and the rate of bombardment outside the football walls outnumbered the rate of bombardment within the football walls; in this case, the hardness of the football decreases" (The third figure in Appendix).

B-The participant autobiography journal referred his alternative concept, he held earlier, to the positivist curriculum that he had subjected to, at school; the curriculum used the positivist approach in designing a preplanned experiment to guide discovery. This way of presentation leads to recycle historical ideas, by considering air pressure as a continuous column of air particles that has a perpendicular accumulated force effect exert on the unit area of football walls, (no space between particles –The first figure in Appendix).

C. The misconception that student held before instruction, imitates 19$^{th}$ century view, in considering pressure, as a column of continuous air particles adjacent to each other, exerting their perpendicular accumulated force on the unit area of the surface (no space between particles). Although the work of Einstein gives clear evidence about the existence of empty space between air particles, and that light rays reach earth surface by itself, it doesn't need medium to translate its wave through, however, the mental image of early scientists in their believing in the continuity of the universe (no space between particles), is still implied in the traditional definition of air pressure in science textbooks.

D. The participant journal also gives another reason for his misconception, in that; "positivist curriculum did not give a comprehensive view about phenomena. The pressure concept is represented isolated from the gravity concept, and the components of atmospheric particles are represented isolated from both". This way of representation did not help student in making comprehensive view in explaining phenomena. The participant drawing after restructuring his idea shows air particles distributed evenly, and more adjacent to each other at valley than at hills, (the second figure in appendix); his new image explains the less hardness of the football at valley in that; "at valley, air particles exert stronger exterior perpendicular forces at football surface, outnumber interior ones" (the fourth figure in Appendix). The participant questioned his old naive view; in saying "how it could be possible that pumping a limited quantity of air particles, would be equal to a column of exterior continuous atmospheric particles" (the third figure in Appendix)".

E. The autobiography of participant journal shows that using drawings to clarify specific concepts is rather far more beneficial, than presenting YouTube videos from website, programmed to benefit common purposes. Imagination drawings to be used in representing phenomena would be of great of help in restructuring alternative concepts and evaluating their success. Students' drawings could benefit in making exact diagnosis for their idea, besides, guiding its restructuring (the first and the second figures in Appendix),,

**Discussion**: The findings of the study show that in order to get rid of students' misconceptions regarding core scientific ideas that works as a critical barrier to understand other scientific concepts, they should have a comprehensive scientific concept regarding phenomena, curriculum developers should take into their account the followings:

A. Using concrete tangible observable forms in representing scientific concepts in order to clarify abstract microscopic idea in textbooks (imagination drawings particulate model in this study). These findings agree with the works of Kilani and Zuibi, 2014, Newby, T., &Stepich, D., 1987, El-Kilani, S, Doulat, A., &Alwraikat, M.,2012, Jacobson,, &Archodidou, 2000.

B. It is so important that curriculum developers should take into their consideration, the ideological, epistemological and pedagogical dimensions in such development. Such consideration would help in getting rid of the positivist 19$^{th}$ century assumptions about nature of matter; the positivist approach had led to base instruction on discovery methods that had been used to prove the historical ideas. The study findings show that more attention should be directed to present the declarative microscopic knowledge about particulate nature of matter, and not to depend on students, to discover great ideas by macroscopic tools; otherwise such experiments, would work to enhance their alternative conception. Students were familiar with the phenomena in the question at macroscopic level (football deflating), however, positivists' methods was not enough in representing the behavior of particles in the gaseous state. The findings agree with the great epistemological work in science education; Schwab, 1964, Shulman &Tamir, 1973, Carey, 1984, Novak and Gowin 1986, Mckenna, S, 2004, Kincheloe, J. 2005, Pocovi' (2001), Kiraly, D., 2015.

C. The findings of the study show that the main misconception students held was their imagination of a subtle universe without empty space between particles. Curriculum developers should take into consideration, forming a coherent mental microscopic dynamic imaginative picture about atmospheric pressure; through designing a visual three dimensional dynamic picture that takes into account space, place and time. Analogies drawings, rather than You Tube videos, should be used to clarify specific abstract concepts. This strategy would have a great help in letting students distinguish between alternative ideas and the scientific particulate mode about nature of matter. This finding agrees with the works of El- Kilani, et.. all. 2012, Staver & Lumpe (1993), Johnstone (1993), Jacobson, & Archodidou, 2000.

D. The findings of the study show that particulate theory of matter is a core concept, and it works as a critical barrier to understand a wide range of phenomena. The findings suggest that particulate theory should be introduced very simply at elementary stage, and then to be developed gradually with activities, that are tailored into many students' abilities. In addition, reference should be made to the particulate model in such gradual development, to reinforce students' idea about the concept. The curriculum should be developed so that important ideas as pressure are revisited to be agreeable with the latest scientific point of view. This procedure should go with providing, opportunities to let students revisit their ideas in multiple context; such revision would help in consolidating students' ideas in making proper connections between earlier and later work in history of science. Science educates should make a careful planning of curriculum and teaching schemes, while providing opportunities for consolidation and reinforcement of basic ideas in different topic areas throughout the years of secondary education, rather than assuming that science ideas are adequately grasped when they are first introduced. These suggestions are agreeable with the work of Dow, Auld and Wilson, 1978.

E. A comprehensive view that takes into account all factors to explain a given phenomena should be considered in planning curriculum. The pressure concept should be linked to the gravity, and the atmospheric components themes. This finding agrees with the work of Kiraly, D., 2015, who called for a wholeness view of learning process that goes beyond learner self experience into a post-positivist curriculum development model.

**Conclusion:** The findings of the study show that the ideological, epistemological and pedagogical dimensions should be taken into consideration during curriculum development; such consideration would help in getting rid of the positivist 19$^{th}$ century assumptions about nature of matter; the positivist approach in designing curriculum had led to base instruction on discovery methods that had been used to prove the historical ideas; such method had led students to have an image of a subtle universe without empty space between particles. This means that curriculum developers should take into consideration using a concrete tangible observable forms in representing scientific concept, such way of representation would help in forming a comprehensive view that takes into account all factors to explain a given phenomena in planning curriculum. Students should form a coherent mental microscopic dynamic imaginative picture about atmospheric components in order to understand core scientific ideas such as atmospheric pressure;. The pressure concept should be linked to the gravity, and the atmospheric components themes with a visual three dimensional dynamic picture that takes into account space, place and time. Analogies drawings, rather than You Tube videos, should be used to clarify specific abstract concepts.

**References**


[1] Available online at www.sciencedirect.com

[2] Carey, S., (1984),"Reorganization of knowledge in the course of acquisition", Unpublished paper, Massachusetts Institute of Technology.

[3] Dow, W., Auld, J., &Wilson, D., (1978) "Pupils concepts of gases liquids and solids (an investigation into teaching of the particulate nature of matter), Dundee college of Education.

[4] El-Kilani, S, Doulat, A., & Alwraikat, M (2012). "The effect of PCK on solving selected chemistry problems"., International Journal of Humanity and Social Science, JHSS, 2, ( 6)

[5] El-Kilani. S, Zuabi, R., (2014) "Fitting various instructional strategies into various domains of scientific knowledge", European Scientific Journal, republished in Procedia - Social and Behavioral Sciences 143, P. 195 – 198

[6] Jacobson, M., & Archodidou, A., (2000)," The designing of hypermedia tools for learning: Fostering conceptual change and transfer of complex scientific knowledge" . Learning Science, 9,145- 199.

[7] Johnstone, A (1993)," The development of chemistry teaching: A changing response to changing demand", Journal of chemical education, 70, 701-704.

[8] Kilickaya, B., (2017) .The New Turkey. On Line.Kortland, K., (1996) "An STS case study about students' decision making on the waste issue" Science Education" 80, 673-689.

[9] Kincheloe, J., (2005)."Classroom Teaching: An Introduction." NY: Peter Lang.

[10] Kiraly, D., 2015 "Towards Authentic Experiential Learning in Translator Education". Publisher: V&R Press

[11] Lieto**, A.,** Damiano, R., Michielon, V., 2014, "Conceptuel Modelas for Intangible Art. A formal modeling proposal" Mesis Journal**,** 3, 2, **P.** 70-78

[12] Littledyke, M., (1996) Ideology, Epistemology, Pedagogy and the National Curriculum for Science: the influence on primary science, Curriculum Studies, 4:1, 119-139.

[13] Mckenaa, 2004 "Paradigms of curriculum design: Implications for South African educators" DOI: .4314/jlt.v37i2.6016.

[14] Newby' T., & Donald A. Stepich (1986), "Learning Abstract Concepts: The Use of Analogies as a Meditational Strategy."Journal of Instructional Development. Vol.10, No. 2.

[15] Novak, J., &Gowin, D. (1984) "Learning how to learn". Cambridge University Press

[16] Pocovi', M., (2001), "The effects of a history-based instructional material," journal of Research in Science Teaching 44 (1) 107-132

[17] R.A. Duschl and R.J. Hamilton (Eds), philosophy of science, cognitive psychology, and educational theory and practice, (pp. 147-176).New York State, University of New York Press.

[18] Schwab, J., (1964) "The Structure of the Discipline: Meaning and Significance, "In G. W. Ford and Lipugno (eds.), The Structure of Knowledge and the Curriculum, Chicago: Rand McNally , pp. 1-30..

[19] Shaepardson, D., & Pizzini, E., (1991), "Questioning levels of junior high school science textbook and their implications for learning textual information" Science Education, 75, 673-682.

[20] Shulman, L., &Tamir, P., (1973) "Research on Teaching in the Natural Science" in R. M. W. Travers (Ed.), Second Handbook of Research on Teaching>. Chicago: Rand McNally, p 1098-1118.

**[21]** Staver, J., &Lumpe, A. (1993), "A content analysis of the presentation of the mole concept in Chemistry textbooks".Journal of Research in Science Teaching, 30 (4), 321-337.

[22] Strike, K., & Posner, J., (1992) "A revisionist theory of conceptual change" In

[23] Zaid, S (1988); "Teaching for understanding scientific concepts and principles using meta-procedural reorganization", Unpublished Dissertation, MSU.