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Teachers' Epistemological Beliefs: A Case Study of Teachers' Meaning of the Process of Explanation

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ABSTRACT *The aim of this study is to identify Greek science teachers' practices during science teaching related to the process of explanation. Given that teaching practices convey epistemological and other beliefs, the study explores their epistemological beliefs related to explanation. Beyond the philosophical interest for the role explanation in science, researchers investigate learners' explanations, because these explanations may be false, insufficient, or may reveal misunderstandings, etc. Forty-six secondary science teachers voluntarily answered a questionnaire. Analysis of their responses indicated that they form four quite different groups based on certain criteria, such as their knowledge in producing explanations, their teaching practices relative to explanation, the relation between explanation and understanding, and the role of explanation in the evolution of scientific theories. The results also indicated that the majority of them prefer teacher-centred explanations, tend to overestimate explanations' contribution in understanding, and do not offer scientifically correct explanations.*

KEY WORDS: *Explanation, philosophy of Science, science teachers' beliefs, teaching practices, understanding.*

Introduction

The most common way to define an explanation is to state that it "Is the answer to a why-question." Every person has the experience of posing and answering a "why-question." Depending on the context of the discussion or the context of situation, answers may be sorted in categories, such as the naïve causality, the common sense reasoning, the folk psychology, the anthropomorphic, the teleological, etc. Anthropomorphic explanations are those who attribute to inanimate world characteristics such as motivation, intention, etc. For example, the sprout of the plant wants to look at the sun, and, thus, it seeks to go out of the box. An example of naïve causality is "the little child is the cause for the broken vase." Common sense explanations are based on common sense logic and are used in every day discourse about issues, such as the weather, the inflation, the criminality, etc. Teleological explanations are those when something happens in order to induce or to facilitate something else to happen, or to come to its end. For example, the four seasons serve the fruitage and the food production.

In science classrooms and across different levels of education, learners ask for explanations or teachers offer explanation to the learners. The kind, the quality, the aim, or even the frequency of these explanations attracted the interest of research during the last twenty years and earlier. Examination of these explanations from the point of view of Philosophy, different learning theories, or in terms of student outcomes, led to different taxonomies of explanations, indicating both strong and weak points of each taxonomy and useful proposals for science teaching. As indicated in the literature, there is still a continuing debate concerning the role of explanations in science teaching. A search in the ERIC database using as keywords "Explanation" and "Science Teaching" resulted in a list of 128 articles and other publications. Only few of these publications focused on teaching practice and teachers' beliefs. Several researchers (Horwood, 1988; Douglas, 1991; Edgington, 1997) analyze the different modes of explanation that teachers use in their teaching. The present study addresses the same objective although the context is quite different. The study attempts to a) to identify teachers' practices relative to explanation and b) to identify teachers' beliefs about explanation in science and in science teaching. Evidence of this attempt will finally employed to offer guidelines for the design and development of an in-service training program aiming to improve these strategies and practices.

Review of Literature

Explanation: The philosophical perspective

Aristotle in his "Physics II" proposed that humans employ four different types of causes (material, formal, efficient, and final) in order to explain what goes on around us. Material cause is that in which a change is brought about. Formal cause is that in which something is changed. Efficient cause is that which brings about some change. Final cause is that end or purpose for which a change is produced. An example of Aristotle's logic on causation is this: A statue is produced by a sculptor (efficient cause), by imposing changes upon a piece of marble (material cause), for the purpose of possessing a beautiful object (final cause), the marble thereby acquiring the form, or distinctive properties, of a stature (formal cause). Since then, the restriction of the metaphysical element in explaining the natural phenomena became a route leading to the spiritual liberation from the theological dogmas. Science explained phenomena known from ages, such as the tides, the fermentations, the epidemics, etc, or proposed explanations for phenomena such as the heredity, the earthquakes, the evolution of species, etc. The philosophical discussion about explanation and its role in Science gains interest after Hemplel and Oppenheim's work "Studies in the logic of explanation" appeared in 1948. Since then, a vigorous discussion is going on and explanation is placed in the center of the debate among realists and empiricists, naturalists and realists, etc. Every perspective puts different emphasis on explanation and reveals the weaknesses of the opposite perspective as presented in Salmon's (1990) or van Fraassen's (1980) works. The main types of scientific explanation, which are useful for the present study, are presented in Table 1.

Although there are major or minor disagreements between these rival perspectives, there are few theses about explanation that are widely accepted. The first is that "explanation is different from description." For example, the explanation of change of the pressure of a gas in a cylinder, according to ideal gas law $PV = nRT$, is different form its explanation due to the collisions of molecules on the walls of cylinder. The second is that explanation is different from prediction, that is, the prediction of a solar eclipse based on past observations and recordings is something different from the explanation.

Table 1
Basic types of explanation

Logico-philosophical view and supporting scientists	Description, main characteristics.
Inferential View (Hempel, Oppenheim) Deductive- Nomological, **(D-N model)** Inductive –Statistical, Deductive- Statistical. **(D-S model)**	An explanation is a type of logical deductive argument, is an inference The premises of the argument are sentences which: a) Describe antecedent conditions, b) Express universal laws of nature, relevant with the premises. The phenomenon to be explained comes as the logical deductive conclusion. It could be predicted from the laws and the antecedent conditions. The label Deductive-Nomological, which is used for this mode of explanation, depicts the two main pillars: the Deductive Logic and the fundamental role of Laws. The laws may be universal, such the Newton's law of gravitational attraction or Statistical laws coming from observations. The function of laws in the premises has driven the discussion to the nature of laws and henceforth to new criticism.
Causal View (Salmon, Lewis)	An explanation is a description of the various causes of the phenomenon. To explain is to give information about the causal history that led to the phenomenon. Salmon insists that an adequate explanation has not been achieved, until the fundamental causal mechanisms of a phenomenon have been articulated. It is deeply reductionistic. Salmon defends his causal realism by rejecting Hume's conception of causation.
Pragmatic View (van Fraassen)	Van Fraassen characterizes explanation as an answer to a why-question. An explanation is a body of information that implies that the phenomenon is more likely than its alternatives. For van Fraassen, an answer will be potentially explanatory if it "favours" the probability of event k, the Pk, over all the other members of the contrasting class. This means roughly that the answer must confer greater probability on Pk than on any other possible event i, the Pi. In his book "The Scientific Image" presents an influential defence of anti-realism. Naming his view "constructive empiricism," van Fraassen claimed that theoretical science was properly construed as a creative process of model construction, rather than one of discovering truths about the unobservable world.

Explanation in the Science Curricula

In Science Education, the explanation is conveyed as a constituent of scientific enterprise. According to the epistemological thesis that dominated in the curriculum design, the explanation has a different role either as an aim of the curriculum, as a process of scientific method, or as a criterion for choosing theories. So, the philosophical discussion about explanation, naturally, is transplanted in the discussion about the role of explanation in science curricula. Issues relevant to the nature of scientific knowledge, the evolution of theories and the explanatory function of theories, are included in science curricula, such as the Project 2061, or are discussed in relation to the teaching strategies (Matthews 2000; Scerri 2001). Without regard to this discussion, past or current science curricula state aims for the explanation. In the U.K. National Curriculum, Single Science Key Stage 4, considering evidence is stated as an important objective: *"Students become able to use diagrams, tables, charts and graphs, and identify and explain patterns or relationships in data... Use scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions."* (National Curriculum online). Similar aim is stated in the USA, NSE Standards 1996. In the Science Content Standards: K9-12, Science as Inquiry, is also stated: *"Students become able to use formulae and revise scientific explanations and models using Logic and evidence" (pp 104-105).*

Explanation as a learning outcome

These aims, as many others in Science Education, are difficult to be attained. Metz (1991) identified three developmental phases in children's ability to explain: function of the object as explanation, connections as explanations, and mechanistic explanations. Secondary school biology students hold out teleological and anthropomorphic reasoning, when they explain phenomena occurred in plants or animals, as found by Tamir and Zohar (1991). Touger, Dufresne, Gerace, and Mestre, (1995) classified college students' explanations in physics in tree categories: intuitive, formula driven, or hierarchical. A lot of research findings are accumulated and learners' explanations are grouped in various categories (Driver et al., 1994; Taber & Watts 2000). Common categories of non-scientifically accepted explanations are the following:

- Naïve causation. Common sense causes and processes are used in explanations, i.e., force is the cause of the motion. If there is no motion, there is no force acting.
- Circular argument: The argument has the form: agent X will cause event Y to happen because agent X has a tendency to cause event Y to happen. Example: vibration is the cause of sound; sound is a type of vibration.
- Teleological. The phenomenon or the change happens in order to facilitate something else to happen or to serve an end, i.e., mutations serve the evolution of species.
- Non-logical. The explanation is based on scientifically accepted basis, but the syllogism is logically wrong, i.e., when we increase the pressure in a gas, the particles come closer and so they collide more frequent.
- Non-scientifically based. The base of the argument is not a scientific one, i.e., fever is a message that something goes wrong in our health.
- Anthropomorphic. Usually is a case of animism. Inanimate world is treated as having emotions or motivation, i.e., similar charges are repelled because they dislike each other.
- Non-coherent. The syllogism used in explanation changes whereas the cases to explained are similar or identical, i.e., the explanation of the refraction is based on the concept of light rays and the explanation of reflection is based on the concept of photons.
- No explanation needed. A belief that the phenomenon is a manifestation of the way the nature works and no explanation is needed, i.e., the day-night cycle, the cycle of life, etc.

- Re-description of the event instead of explanation. Such are the cases where the description, some times as a scientific law, is treated as an explanation, i.e., heating is the cause of the expansion of the rod.

Explanation in the research about teaching and learning

The research results of the "explanation as a learning outcome" were put under the scrutiny of newer theoretical approaches about the learning process. The search about learners' ideas or their pre-existing knowledge employed a tool based on explanation, the Prediction-Observation-Explanation as described by White and Gunstone (1992). The same sequence is promoted as an efficient strategy, which promotes understanding in teaching, as described by Blythe (1998) in "The teaching for understanding project" at Harvard. Explanation is also used as a tool for the improvement of learning in two ways. As "self-explanation" is studied by Chi and Bassok (1989), whose findings support the efficacy of the inner dialogue in comprehending examples. As "explanation to others" is studied by Ploetzer et al., (1999), who described five different cases with different effect in learning.

The coincidence between epistemological aspects for the explanation and theoretical views about learning is expressed in some proposed and already used teaching strategies. So, explanation is a basic phase/stage in teaching strategies, such as the 5E Model or the 7E model . The 5E model of instruction is proposed by Bybee (1997) and is based on the Learning Cycle introduced earlier by Karplus and Their (1967). The lesson plan consists of five successive stages: Engagement, Exploration, Explanation, Elaboration, and Evaluation. (Bybee, 1997) A more detailed model, including two more Es, the Elicitation of prior knowledge before the Engagement and the Extension of the acquired knowledge in new cases, is proposed by Eisenkraft (2003). In the Learning Cycle, the 5E and the 7E model, explanation is the phase where students seek for models, or laws or theories, in order to explain their findings form the Exploration phase. It is the phase when teachers present scientific theories as explanatory proposals. It is also possible to use the already known laws, theories, or models for the production of logical explanations. In some cases, models are modified or abandoned in the pursuit of a widely accepted one or in favour of a well-based explanation.

At this stage explanations are offered by learners, or by the teacher, and are discussed or criticized until these satisfy learners' curiosity and understanding.

Teachers' beliefs and practices

Many researchers claim that science teachers hold epistemological beliefs that affect seriously their teaching choices and practices. These beliefs refer to the status and the truth of the scientific knowledge, the role of scientific method, the evolution of theories, the role of explanations in theory formation/change, etc (Gallaher 1993; Duschl & Hamilton 1998). Horwood (1988) brought up the relationship between teachers' explanations and curriculum goals. According to his findings, teachers in their practice include three kinds of explanations, each of which promotes a different picture of science and assigns a different role to the explainer. Yet, Horwood (1988) emphasized the distinction between scientific explanations and teaching explanations. In his view, scientific explanations are for a phenomenon, an event, etc, while teaching explanations are also for a phenomenon and someone, the learner. Furthermore, scientific explanations *"need not be concerned with whether or not the audience, if any, has understood the explanation."* (Horwood, 1988, p. 43) In contrast, Horwood (1988) argues that teaching explanations have to satisfy contradictory demands *"the learner gain understanding (leaving no unanswered questions), without inhibiting future learning"* (p.43). These findings serve as a background for our research. The study of his works as well as the work of Douglas (1991) and Edgington (1997) drive us to classify explanations according to the purposes and the contexts, as presented in the Table 2.

Table 2
Types of explanation according to context and purpose

Context	**Purpose**	**Type of explanation**
School Science	Explanation of phenomena	Scientific explanation
Communication	Understanding	Communicative explanation
Teaching science	Learning science	Didactic explanation

The scientific explanation is produced on the basis of distinct explaining modes, which will be presented in the next paragraph. Communicative explanations are used in order to satisfy learners' understanding of teachers' talk presentations, thinking, etc. Teacher explains his/her reasoning, inferences, choices, etc, instead of going through the same steps in reasoning, inferring, or problem solving. Didactic explanations are those which are both scientific and communicative, aiming to present an understandable scientific explanation for a phenomenon. This type of explanation should be the more frequent in science teaching sessions.

Sample –Tool- Method of elaboration

The sample of our research consisted of forty-six (46) secondary science teachers in the area of Athens who voluntarily participated. The sample has the characteristics of a Case Study sampling. The tool of research was a questionnaire of eight (8) free response questions that were chosen in order to support mutual cross-check. Three questions asked for teachers' epistemological beliefs, two questions called teachers to write examples of explanations, and the rest surveyed their practices relative to explanation.

The way of elaboration is based on ethnographic methodology. Teachers' answers in every question were compared and classified in groups according to their meaning. Moreover the groups from each question were crosschecked with the categories from other questions in order to compose the categories of beliefs and the categories of practices. These categories form four "teachers' profiles" relative to explanation, as described in the Table 3.

Each cell in Table 3 describes a "teacher's profile" relative to the explanation. His / her beliefs and knowledge about explanations, the goal of the explanation during teaching, and the quality of their explanations are coherent. The majority of the sample (91,3%) were classified in the four profiles. Only four teachers (8,7% of the sample) formed the "Eclectic, non-coherent" category. These teachers hold non-coherent beliefs, or non-coherent beliefs and practices. They are eclectic in the sense that they act differently from what they think about explanation.

Table 3
Teachers' Profiles

	Teaching practices	
Knowledge and beliefs	**A** Teacher centered. Lack of knowledge or incorrect knowledge relative to explanations. Aim is the understanding. Teacher presents explanations included in textbooks. Repetition is the remedy for misunderstanding or not-understanding the explanations. Produce and teach inadequate partially wrong explanations, telonomical, non-logical, etc.	**C** Science centered. Science explains, reveal causes, discover laws, and produce theories. *Learning science will make you able to explain the world and the phenomena.* Aim goes beyond the scientific knowledge to the adoration and the status of Science. Learners' duty is to attend, to understand, to study, and learn Science. Produce or teach scientifically correct explanations.
	B Teacher centered. Use correctly the D-N or the D-S or the causal explanation. Aim is the Understanding. Almost all phenomena can be explained or reduced to fundamental causes. Repetition is the remedy for misunderstanding or not-understanding the explanations.	**D** Learner centered. Scientific explanations, as well as other explanations, are customized to the learner(s). Understanding explanations is the aim and the only criterion. The accomplishment of this goal has side effects, such as incomplete, partially wrong, circular or naïve explanations.

Findinds and Discussion

The distribution of the sample in the above-described profiles is presented in Table 4.

Table 4
Distribution of Teachers' Profiles

	Main attributes of the profile	Frequency	Percent	Valid Percent
	Eclectic, non coherent	4	8,7	8,7
B	Teacher centered. Main aim is to Understand. Correct examples of explanation.	6	13,0	13,0
C	Science centered. Main aim is the specific status of Science, the scientific knowledge that explains. Correct examples of explanation.	9	19,6	19,6
A	Teacher centered. Main aim is to understand. Wrong examples of explanation.	13	28,3	28,3
D	Learner centered, The main aim is to understand. Wrong examples of explanation.	14	30,4	30,4
	Total	46	100	100

These results depict some interesting characteristics of the sample.

1. The aim of "understanding" dominates, because is proposed by 71.7% of the sample. So, the didactic explanations presented in Table 1 seem to be more frequent in teaching sessions.
2. The quality of these explanations is inadequate in the 58.7% of the sample. Teachers either do not know how to produce a correct scientific explanation, or they know but they sacrifice the scientific methodological rigidity to the understandability.
3. Very few of them (13%) seem to be able to counterbalance the rigidity of the scientific explanation and the understandability of their reasoning.
4. An interesting profile is the one that sacrifices the understandability to the scientific rigidity in explaining. They hold the belief that explanation should be done by students themselves. Students have to study in order to learn the necessary scientific knowledge and the method of explaining.
5. The role of the teacher is central in two of the four profiles (41.3%), while the learner is the center of the process in one profile (30.4%) and the Science in the last profile (19.6%).
6. Correct or adequate explanations give two profiles: the science-centered teacher and the teacher who can balance the firmness of the scientific explanation with the understandability.

Some of the findings were anticipated from other research findings, such as that of Dagher and Cossman (1992), Tamir and Zohar (1991) and others. Thus, our findings support that the teachers of the sample:

- Lack of correct knowledge about the aim, the processes, the models of explanations and the criteria of their adequacy. Teachers presented wrong examples of explanations, like the ones already known from the research, i.e. cyclical, teleological, non-scientific, non-logical, formula-based, etc.
- Hold epistemological beliefs about the potency of science to explain almost everything, or the special status, which should attribute to Science due her potency to explain the mysteries of nature, etc. They claim that explanation is the main priority of scientific enterprise, and that is strongly correlated to causality or to the reduction to the principles.
- Very few hold the idea that explanations have the same status like the laws and theories, and hence teach explanations in the same way.

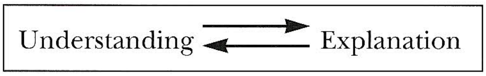
What was unexpected is that teachers of the sample:

- Insist that explanation is a powerful method to promote understanding, or a way to cure misunderstanding.
- They soundly support the close relation between the ability for explanation and the acquisition of knowledge. Teachers use explanation in their teaching strategy, in strengthening knowledge, or in evaluating students' knowledge.

In order to make sense of these unexpected results, we turned to other sources and disciplines for help. Four fields put some light on the close relation between explanation and understanding: 1) The Hermeneutics, 2) the Achinsteins' thesis for the explanation, 3) the Communication theories for understanding, and 4) the current theoretical theses for the role of pre-existing knowledge in learning and understanding.

Explanation and understanding in Hermeneutics

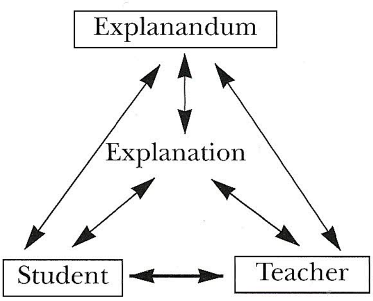
Paul Ricœur's Theory of Interpretation



seeks a dialectical integration of Dilthey's dichotomy of explanation (erklären) and understanding (verstehen). In teaching, both explanation and understanding are used frequently for purposes described in Table 2. According to this theory, both explanation and understanding interact and fabricate the comprehension. At the beginning, understanding will be a naïve grasping of the meaning of the text as a whole. The second time, comprehension will be a sophisticated mode of understanding supported by explanatory procedures. Explanation, will then appear as the mediation between two stages of understanding.

The Achinstein's proposal

Peter Achinstein (1983) developed a challenging theory for explanation. Achinstein characterizes explanation as the pursuit of understanding. He defines the act of explanation as the attempt by which one person tries to promote understanding in another person by answering a certain kind of question in a certain kind of way. Since someone is giving an explanation to somebody else, who seeks to understand, the question resembles the question "what does it mean to understand?" Obviously, the reflexivity of the relationship between explaining and understanding cannot be ignored. Achinstein (1983) included these considerations in a general model stating that an explanation (***E***) depends on who (***A***, i.e. the teacher, the expert) explains, what (q, the issue to be explained, the explanandum), to whom (***S***, i.e. the student, the inquirer). Explanation (***E***) may be a fact, a sentence or anything else that a person, the student, will find "illuminating." The criteria for a satisfactory explanation ***E*** require that S understands the explanation itself. They depend on the knowledge and concerns of those in ***S*** including relevance, correctness, and depth.



The two main theses are:

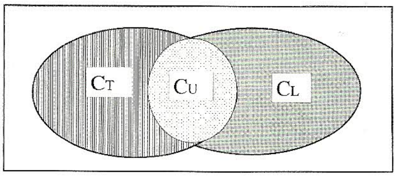
- The explanation (E) depends on who explains (A), what is to be explained (q), to whom (S).
- An answer is explanation (E), if and only if satisfies the S.

These theses offer "amnesty" for the "profile D" teachers, the majority of our sample, who set as principal goal the understanding against to scientifically correct explanations. They also help us to understand the reason for the great peculiarity of explanations that teachers produce in their teaching. One more advocate of this idea is Newton (2000). For him *"The aim of Science is understanding."* In his own words, *".., a mature science goes beyond the acquisition, description and tabulation of facts and makes understanding its main aim"* (p. 45).

Explanation and understanding, the role of the context

The role of the context is determinant in understanding among discussants, or in a one-way communication like the traditional teacher-centered teaching. According to White (1988), understanding can be presented using Venn Diagrams. Everything that the learner knows and uses efficiently in the process of understanding, new information or new experiences, is presented as set C_L. The classroom setting, the already taught science content, the teacher's content and pedagogical knowledge comprise the teacher's context, the set C_T. Their common context is $(C_T \cap C_L)$ and is the locus where they communicate effectively, as it is presented in Figure 1.

Teachers use not only the scientific knowledge C_T but also they use elements from students' knowledge C_L in order to produce understandable explanations. Thus, their explanations may include vague elements, may omit something, may be mistaken, or use false–logic, etc. Figure 1 explains the claims made by the teachers of our sample that *"when students know science, they can produce correct explanations,"* or that *"a low-level class push you to do low quality teaching, unless you want to disappoint them."* The larger the $(C_T \cap C_L)$, the more possible is to meet a correct and complete explanation presented by the teacher. For example, if the learner has a sound knowledge of the ideal gas model, a subset of teacher's scientific knowledge in the topic, has a large $(C_T \cap C_L)$. In this case teacher can easily create scientifically correct explanations for phenomena like adiabatic cooling that will be easily understood by the learners. In the opposite case, the learners will misunderstand or cannot understand teacher's explanations or the explanations will not be a very simple one, and hence not scientifically correct.



C_T Context of school science used by teacher (The Explainer).
C_L Context of learner who asks for explanation.
C_U Teacher's and learner's Common Context. The appropriate context for the production and the comprehension of explanations.

Figure 1

Understanding and learning in Piaget's and Ausubel's theory

The overarching idea in Ausubel's theory is that knowledge is hierarchically organized; that new information is meaningful to the extent that it can be related (attached, anchored) to what is already known. The role of pre-existing knowledge is emphasized in Ausubel's work (Ausubel, 1978) that proposed four processes by which meaningful learning can occur via the Derivative or the Correlative subsumption, the Superordinate, and the Combinatorial learning.

1. **Derivative subsumption**. This describes the situation in which the new information someone learns is an instance or an example of a concept that he already knows. When someone knows a lot about trees, for example, that a tree has a trunk, branches, green leaves, and may have some kind of fruit, and that when fully grown is likely to be at least 4-6 meter tall, then when he investigates a new kind of a tree in a botanic museum, he finally decides that this tree is exactly as he/she imagined, based on his/her knowledge.
2. **Correlative subsumption**. In this situation, the learner has to alter or extend his/her concept for something in order to be correlated with a new different version of what he /she already knows. The learner sees for the first time a

new kind of tree with red leaves. After some exploration, he/she decides that it belongs to the same type of trees he /she knows. In a sense, you might say that this is more "valuable" learning than that of derivative subsumption, since it enriches the concept.

3. **Superordinate learning**. In this case, the learner already knows many examples of the concept, but he/she does not know the concept itself until it was taught to him/her. As an example, a superordinate concept for a group of trees is the concept of spermatophyta, the plants that are producing seeds for their reproduction.
4. **Combinatorial learning.** The first three learning processes involve new information that "attaches" to a hierarchy at a level that is either below or above the previously acquired knowledge. Combinatorial learning is different; it describes a process by which the new idea is derived from another idea that is neither higher nor lower in the hierarchy, but at the same level (in a different, but related, "branch"). So, he/she may learn that a group of trees he /she already knows belong to the category of Dioecious, i.e., species having male and female plants (that is, only male flowers on some plants and only female flowers on different plants).

These processes are similar to the assimilation process described by Piaget. Assimilation, to put simply, is taking in new information and trying to fit this information into existing schemas, or responding to the environment in terms of previously learned patterns of behaviour or schemas. When individual's perception of the new experience fits into existing schemas, then there is equilibrium or balance. When existing schemas cannot deal with new experiences there is disequilibrium. This is usually expressed as "non understanding." According to the situation, schemas might change in order to fit the new information, as described by the process of Accommodation. Accommodation is modifying existing schemas to fit the new information, or responding to the environment in a new manner, because the previously learned patterns of behaviour or schemas are not sufficient.

These processes resemble the process of explanation as described in the Deductive Nomological or Deductive Statistical model. These similarities are presented in Table 5.

Table 5
Similarities between Understanding and Explanation

Explanation	Understanding
• In the D-N or the D-S model, the explanandum is correlated with a general, true and already existing law.	• In learning theories, the new information or experience is interrelated to the pre-existing knowledge as described in the Subsumption of the new or the Assimilation (fit in existing).
• The explanation is like to make a prediction or to estimate statistically a possible event. This process is based on the scientific knowledge and the Logic.	• Students use their knowledge and logic to predict the evolution of a situation, the outcome of an experiment, the end of the story, etc. This is the understanding in the dialectical interaction with explanation, as described in Interpretation.

This resemblance might be blamed as a possible source of confusion. Teachers use the mechanism of explanation not only to explain the phenomena but also to facilitate the understanding. Use the scientific laws and theories to explain to the students, use student's knowledge to present reasoning that facilitate understanding.

Conclusions

1. Although teachers lack of specific knowledge from the Cognitive Science, the Communication Theory, the Philosophical study of explanation, or they ignore approaches such as proposed by Achinstein, they have empirically come to significant conclusions about explanation and understanding. They try to attain the goals of understanding and meaningful learning through the exploitation or the misuse of explanation. They try to estimate learner's cognitive domain and then start thinking aloud to show how they subsume or assimilate the new to the pre-existing knowledge. The process of explanation, as carried out in the D-N model, functions as a known prototype in an analogical reasoning mode of thinking. In this attempt, they do mistakes, especially against the meticulousness of scientific explanation.
2. The misuse of communicative explanation for the cure of lack of understanding or misunderstanding might calm down students cognitive disequilibrium or ceases metacognitive awareness about the inappropriateness of their knowledge. So, they do not help learners to change their conceptual frameworks. Conceptual change demands the utilization of disequilibrium and the use of specific strategies and teaching tolls, such as those proposed by the socio-cognitive and constructivistic approaches.

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