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Promoting science teacher education through dissonance and discrepancy

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PROMOTING SCIENCE TEACHER EDUCATION THROUGH DISSONANCE AND DISCREPANCY

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Abstract

While inquiry in science teaching has found a great deal of acceptance (Collette and Chiapetta, 1989), there is a growing recognition that educators need a wider repertoire of inquiry strategies applicable to various situations. One promising approach is through the use of so-called 'dissonant' or 'discrepant events'. This concept of discrepancy can be traced to the early work of Festinger (1957) and his Theory of Cognitive Dissonance" in which he stated that the creation of dissonance is psychologically very uncomfortable and motivates individuals to actively reduce the level of dissonance and thereby return to a state of greater equilibrium or consonance. This approach is consistent with current research in the area of conceptual change (Stofflett, 1994) which maintains that students' dissatisfaction with their existing conceptions constitutes a fundamental condition in bringing about meaningful cognitive change. This paper presents innovative ways of initiating inquiry in the classroom using a number of discrepant events in science designed to promote student curiosity and learning. The generalized use of conceptual conflict is discussed in relation to a number of research findings in this area. Implications of this strategy appropriate for teacher education are also presented and discussed.

INTRODUCTION

Constructivism is emerging as the dominant learning model in science educational reform today. An impressive body of research has been amassed under this paradigm during the past twenty years. Collectively these studies indicate that learners' constructions of science knowledge are highly dependent upon their own theories and models to explain the nature of reality.

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Identifying and building upon the conceptual ecology of the science learner is an important direction in the constructivist approach and has resulted in a far greater understanding of the nature and scope of 'misconceptions' or alternate frameworks held by learners.

One area however which has not received adequate attention is the formulation of appropriate instructional strategies for constructivist education relevant to science classroom teaching and learning. This paper presents a generalized teaching strategy, within the constructivist model, which utilizes cognitive dissonance or discrepancy to foster positive conceptual change.

Discrepancy refers to a dissonant situation where the outcome is contrary to what the learner expects This results in arousal of conflict with a consequent need for the learner to assimilate the unknown or incongruous material into his or her cognitive structure. To accomplish this, the learner engages in exploratory behaviour, because it compels the learner to resolve the discrepancy between what was expected and what actually happened. It is therefore a state of conceptual conflict, where the learner confronts a situation which is in direct conflict to what was expected. Hence the perplexity, incongruity, and contradiction play an important role in stimulating the learner's curiosity. Examples of discrepant events are also described as surprising, counter-intuitive, unexpected, paradoxical, and intuition-offending. All refer to the ability to arouse strong feelings within the participant.

Early reference to the role and nature of dissonance in cognition can be found in Piaget's (Inhelder and Piaget, 1958) notion of 'equilibration' and his contention that thought processes naturally tend towards states of increasingly stable equilibrium through a variety of specific forms, including accommodation and assimilation. Piaget used the term equilibration which denotes a dynamic process rather than equilibrium which may imply a static or steady state, not characteristic of living organisms.

The concept of discrepancy is generally acknowledged to be attributed to Festinger (1957) and his Theory of Cognitive Dissonance in which he stated that the creation of dissonance is psychological discomforting and motivates individuals to actively reduce the level of dissonance and thereby return to a state of greater equilibrium and stability. That is, resolution of the mental conflict comes about as a result of acquiring a greater understanding of the phenomenon. This normally results, therefore, in a change in the learner's ideas whereby existing ideas are exchanged for those more consistent with those held by scientists.

However, some researchers claim (Posner, et al 1982) that for meaningful conceptual change to take place, the learner must be initially dissatisfied with those ideas currently held. Still, dissatisfaction with a particular view is not, by itself, a sufficient reason for discarding an idea. Students, like scientists, will not normally reject an idea unless they are truly convinced of an attractive alternative. For acceptance of a new idea, (Posner et al, 1982) postulate that all four of the following conditions need to be met. That is the learner must be dissatisfied with the idea and wants to replace it with something which is more intelligible, plausible and fruitful for the learner.

Students and all learners, like scientists, undoubtedly acquire their conceptual understanding for a wide range of other reasons, including how acceptable their ideas are to their peers. However, whatever the reason, it is becoming clear that conceptual change is a highly complex process which occurs gradually. A major problem in science teaching is that, often, the 'scientific viewpoint' presented in the science classroom is less intelligible, plausible, and fruitful, than the student's own conception. If these resilient student conceptions are to be changed, appropriate and effective teaching strategies to address the underlying conditions for conceptual change are urgently needed. The introduction of discrepant events in the science classroom offers considerable potential in this regard.

The work of Liem (1987) has been associated with the classroom application of discrepant events to foster inquiry in science for some years. He contends that arousing curiosity in the learner is the single most important condition for learning retention on a long term basis. Other conditions include:

1. Accompanying the event with familiar information,
2. Establishing extra gateways or avenues for learning,
3. Connecting with familiar experiences to provide the context, and (iv) Providing an enthusiastic and enjoyable atmosphere.

DISCREPANCIES IN SCIENCE

A discrepant event can be used in almost any discipline of knowledge but this technique particularly lends itself to Science and Math teaching. Many common topics, principles and laws are often taught with the help of simple apparatus. Even abstract concepts like numbers, etc., can be demonstrated using basic aids. However there is a difference between an ordinary presentation and demonstration and one using a discrepant event. First, the intent is different. The purpose is not only information but to show something that will puzzle and challenge the learner. For example, everybody has seen, and expects, an object to fall downward. However, if an object is shown to fall upwards then it is constitutes a discrepancy which needs explanation.

Hence the manner in which a discrepant event is presented is very important. It is essential that very simple, common, materials from everyday life are used which the student recognizes. Also the science concept should be tied to everyday life. Isolated events taught out of context become meaningless.

The teacher must exercise care in selecting events and problems that are used to influence self-regulation and inquiry. Conditions must be constructed that present a relevant challenge to students but can be intellectually understood and resolved, given proper guidance and time.
Three examples of discrepant events are presented:

<u>Discrepant Event #1</u>: THE CASE OF THE CONFUSED JARS

<u>Concept Demonstrated</u>: Cold liquids are denser than warm liquids

<u>Procedure</u>: Two glass jars are filled with warm and cold water coloured yellow with a drop of food colouring. Two other identical jars are also filled with warm and cold water but coloured with a different colour, red in this case. First, the jar containing the cold yellow solution is covered with a stiff card and inverted over the warm red solution. The two solutions mix at once (see figure 1a). For the second part of the demonstration, invert the warm yellow solution over the cold red solution (see figure-1b). This time the solutions will not mix and they will remain separated for as long as the temperatures are not equalized, which may be as long as an hour. The cold red column of solution being denser than the warm yellow solution supports it.

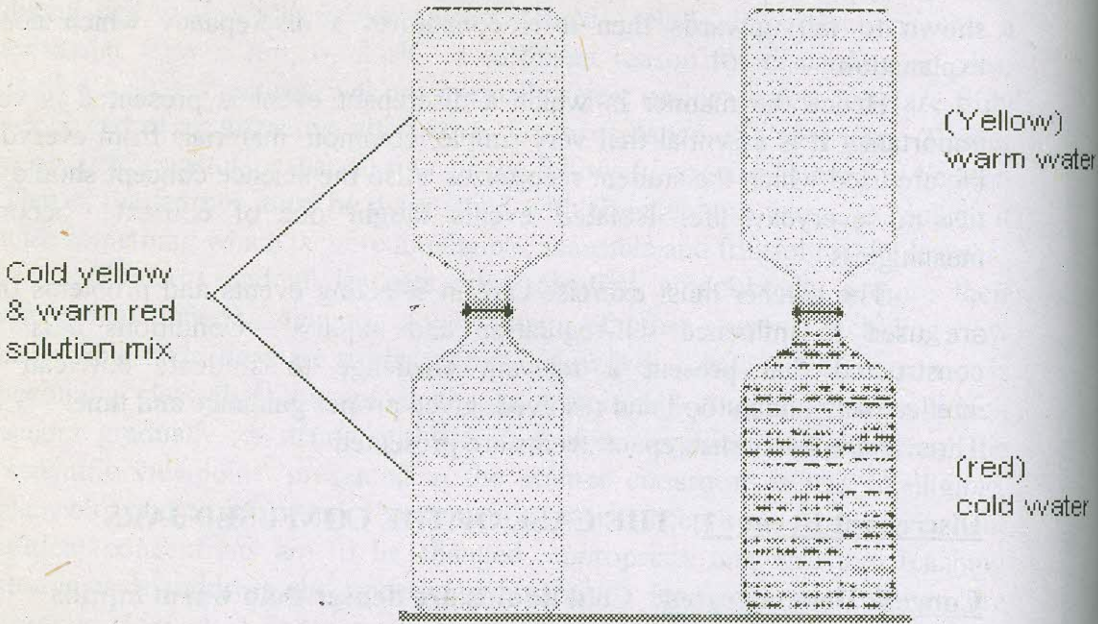

Figure-1a Figure-1b

Discrepant Event #2: THE HEAVY NEWSPAPER[1]

Concept Demonstrated: Air exerts pressure.

Procedure: Take an ordinary wooden ruler or a wooden slat, put it on the table in such a way that it extends 4-6" beyond the edge (see figure-2).

[1] Taken from:
Liem, T.L. (1987). Invitations to science inquiry. (2nd ed.). Chino Hills, CA: Science Inquiry Enterprises.

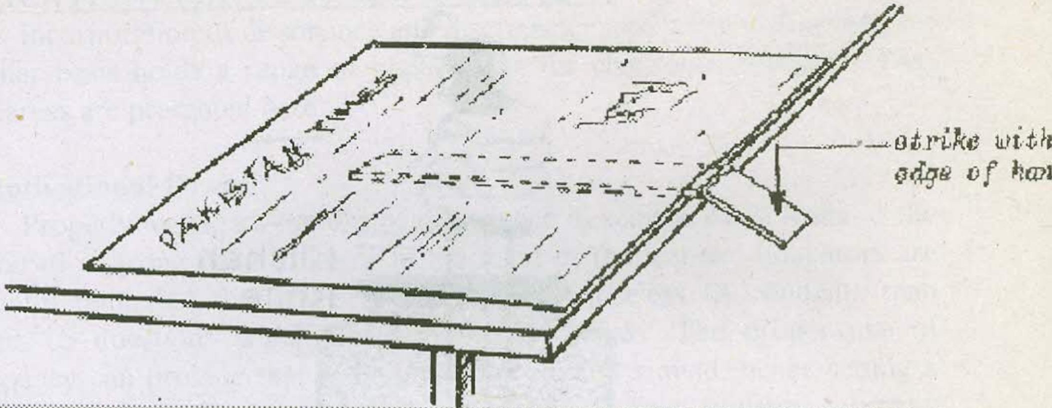

figure-2

Cover it with a single double-sheet of an ordinary newspaper. Smooth the newspaper over the table so that no air pockets remain under it. Then bring the edge of your hand over the extending wooden ruler and strike it sharply. The ruler breaks into two. The pressure exerted on the flattened newspaper and wooden slat by the atmosphere is greater than the force striking the slat, but only if no air is permitted to remain under the newspaper.

Discrepant Event #3: THE STICKY RICE[2]

Concept Demonstrated: Molecular 'packing'

Procedure: Pour uncooked rice grains loosely into a medium-necked large bottle until the bottle is completely full. Plunge the blade of an ordinary kitchen knife into the rice grains several times (see figure-3).

[2] Taken from:
Liem, T.L. (1991). Invitations to science inquiry: Supplement to 1st and 2nd edition. Chino Hills, CA: Science Inquiry Enterprises.

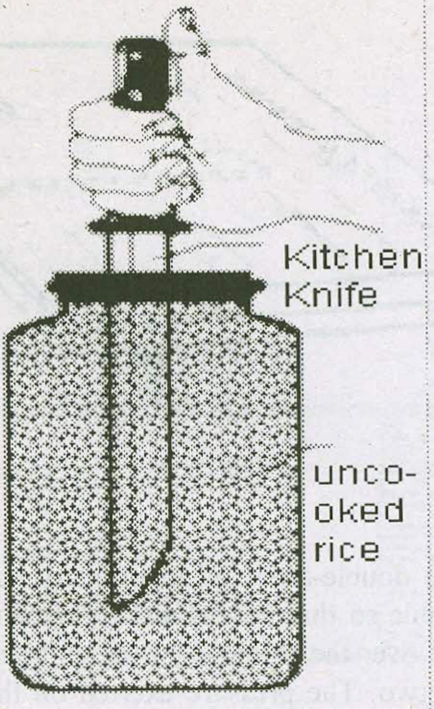

Figure-3

After, maybe the fifth or sixth attempt the bottle will lift with the knife. Plunging the knife into the rice packs them tightly into the jar. The packed grains act as one piece and the whole jar lifts with the knife. After plunging the knife several times into the grains they get packed together. The packed grains act as one piece and the whole jar lifts with the knife.

Factors to Consider When Using Discrepant Events

While using discrepancies the teacher should keep several factors in mind.

1. Provide opportunities for the learners to develop tentative hypotheses about the events. Engage learners in ways they may be able to test their hypotheses.
2. Encourage the learners to ask open-ended questions in a logical sequence. Draw on learners previous knowledge to facilitate students discovering the concepts themselves. Challenge their thinking by providing as little information as possible at the start of the learning experience.

IMPLICATIONS FOR TEACHER EDUCATION

Incorporation of dissonance and discrepancy into science education on a regular basis holds a range of implications for classroom practice. Two broad areas are presented here:

A). Motivational Power

Properly managed, the use of dissonance in science often leads to the creation of a strong need to know in the mind of the learner. Educators are constantly reminded that there is nothing more useless for students than answers to questions which are not in their minds. The proper use of discrepancy can provide that question in the student's mind, hence setting a psychological basis for effective learning to occur. That students construct meaning for themselves as they attempt to make sense out of their interactions with the natural and technological worlds they live in, is a given. This will occur whether we like it or not. The introduction of discrepancies in science provides a vehicle for a wide range of student understandings to manifest themselves by investigating and exploring ideas associated with the event, by students asking questions, at their level, about the event, and by seeking and developing alternate explanations about the event that are seen to be useful and sensible to the student. In this sense discrepant events can be viewed as 'conceptual springboards' to probe existing student ideas in science. Hence 'discrepancy' becomes a powerful tool in the hands of the classroom teacher to gain valuable insight into the nature and level of student thinking.

B).Advantages

The use of discrepancy in science offers a variety of distinct advantages to the classroom science teacher, consistent with sound pedagogical practice. Many of these advantages seem specially relevant to problems encountered in teaching science in the developing world.

1) Motivation. As discussed above, discrepant events can be powerful motivator to generate curiosity in students by establishing an often missing ingredient in science education -- that of the 'need to know'.

2) Relevancy. Most events have an obvious application or relevancy to the students' real world. If this link is not obvious, then the science teacher has a responsibility to make the relationship explicit by providing a practical application where the key idea or principle is operative in an everyday sense.

3) Hands-on. All discrepant events involve simple, concrete materials, which students can manipulate directly.
4) Low Cost. Generally speaking, the needed equipment involved in most discrepant events is inexpensive and readily available. Many events utilize disposable equipment that would usually be found in the 'average' household.
5) Open-ended. Much of the discussion that leads naturally from conducting discrepant events with students is highly consistent with the nature of science itself. That is, they raise additional questions themselves, which lend themselves well to further investigations.
6) Curriculum Related. The available discrepant events on various topics and sub-topics is impressive and runs into the hundreds. This is attractive to the science teacher in choosing particular events which relate directly to current topics under discussion from the prescribed curriculum. Tik Liem is a resource that the authors would recommend highly.
7) Challenging. While many events draw upon simple equipment and materials, the actual concepts and principles involved are often very profound and challenging to the student. In some instances, it may be that the simplicity of the event itself adds to its profundity or what some have termed 'profound simplicity'.
8) Flexibility. This attribute may well be the most attractive to the science teacher. Flexibility here refers both to the range of grade levels that specific events can be modified to, but also to the choice available to the teacher of how to present the actual event. That is, the science teacher is able to decide exactly how to set up the event to produce the greatest effect or desired outcome. This results in an impressive degree of flexibility open to the classroom teacher. In this sense the discrepancy is as much an approach to teaching as it is a specific event or incident.

In science, as in other areas in education, there is convincing evidence that students bring a range of alternate frameworks to bear on their classroom learning. These alternate conceptions or constructions lie at the very heart of existing thought on how students learn or construct meaning. It is often difficult for the teacher to be aware of the scope and nature of these conceptions. The utilization of discrepancy in science readily brings these frameworks into active play in the classroom. In this sense, they are consistent with the constructivist school of thought.

Traditional methods of teaching encourage students to view their teachers as the 'keepers' of knowledge and that there is one 'right' way to do things. Science needs to be seen as a human endeavor which is tentative at all times. Respect for evidence is another key attitude to inculcate in teachers and students alike. Discrepancy and dissonance encourage the students and teachers to reflect on what has occurred and bring forth their ideas. It is this process of critical examination of their own ideas and the systematic rejection or acceptance of these ideas that will encourage the change in concepts and help to create knowledge and deeper student understanding.

Cognitive conflict is not restricted to the field of science and may well prove to be a viable classroom strategy for other disciplines. Certainly, there are several obvious opportunities to incorporate discrepant events into the teaching of mathematics and more challenging perhaps would be instances of discrepancy within the social sciences, akin to levels of moral dilemmas drawn from Kolberg's Theory of Moral Development. The possible implications of discrepant events in fields other than math and science is seen to hold considerable promise.

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