October 2007

Module 3 - Formal Reasoning Patterns: Introduction

Module 3

Formal Reasoning Patterns

Introduction

In Piaget's theory, concrete operational reasoning is characterized by patterns of serial ordering, simple classification, conservation reasoning, and other operations applied to objects that a person is able to observe or manipulate directly. Formal reasoning patterns include these operations but go beyond them to utilize other processes in situations where one does not deal with tangible objects. Formal patterns often involve proportional reasoning, separation of variables, and combinatorial reasoning.

The film "Formal Reasoning Patterns" Davidson Films, 1976) will enable you to watch two interviews (Dr. Karplus and Dr. Peterson) working with several secondary school students who exhibit concrete or formal operational reasoning patterns while responding to four Piagetian tasks. The young people appearing in this film were enrolled in Berkeley's High Potential program for secondary school students. They were above average in showing talent in some areas of accomplishment, not necessarily in academic achievement.

The students' performances were completely unrehearsed - none of them had prepared for the interview or knew in advance what would be required. The scenes in the film were selected to illustrate the concrete and formal operational reasoning patterns described in Module 2. Though not representative of a random sample of secondary school students, the film demonstrates that a diverse group of such students - a typical high school class, for instance, is likely to reveal both types of reasoning patterns.

Objectives

To assist you in describing and/or identifying responses that indicate concrete and formal reasoning patterns applied to Piagetian tasks.

Procedure

The film is shown in the Module 3 area. It lasts about thirty-five minutes. Before viewing the film, you may want to familiarize yourself with the four tasks used in the film by looking over the film notes found on the next pages.

Film Notes - "Formal Reasoning Patterns"

In the film, Drs. Rita Peterson and Robert Karplus, use the probing clinical interview technique employed by developmental psychologists. They are trying to have the students express their thoughts but NOT to teach them how to solve the tasks. The reference for each task contains additional information about the task and the responses of larger numbers of young people.

1. Proportional Reasoning (Mr. Short/Mr. Tall Puzzle - Karplus, Karplus, and Wollman, 1974)

The Mr. Short/Mr. Tall Puzzle introduced in Module 1 is here used as part of an individual interview rather than as a written assignment for a group of studetns. The student is shown pictures of Mr. Short and Mr. Tall, and has a chain of large paper clips to measure the height of each. The student is then given a chain of #1 paper clips, measures the height of Mr. Short using these, and finally predicts the height of Mr. Tall measured in "smallies."

The young people in the film illustrate both (formal) proportional reasoning and (concrete) additive reasoning applied to this task.

2. Separation and Control of Variables (Flexible Rods - Inhelder and Piaget, 1958)

The task shown in the film makes use of a device consisting of six thin rods clamped horizontally. The rods bend when one, two, or three washers are attached.

This apparatus permits the adjustment and controlled investigation of four variables: l**ength, thickness, material of rods**, and **weight**, or number of washers attached.

To verify the effects of length, for instance, the student has to use one rod and a fixed number of washers, and slide the rod in its holder to vary the length. To determine the effect of material, the same number of washers has to be placed on the two thin rods of different materials extended to the same length. The effect of thickness can be investigated by using two brass rods, since this pair is made of the same material.

As you will see in later modules, the formal reasoning pattern of controlling variables is critical for understanding many college assignments and textbook explanations because most phenomena depend on several variables. Often this reasoning is taken for granted and inadequate explanations are furnished to students who do not yet apply it.

3. Combinatorial Reasoning (Chemical Mixtures - Inhelder and Piaget, 1959)

The "coloring liquids" task shown in the film requires the student to identify the role of each of the four liquids combining with a fifth to form a brown color, the color of iodine. The five liquids are:

1 =dilute sulfuric acid
2 = water
3 = hydrogen peroxide solution
4 = sodium thiosulfate solution
5 =sodium iodide solution

Liquids 1 and 3 are necessary to form the brown color with G by oxidizing the iodide to iodine. Liquid 2 has no effect - it may be added or omitted. Liquid 4 prevents the brown color from forming or eliminates it (when present) by reducing the iodine.

The students working on this task illustrate the difference between (1) formal reasoning which goes through the full range of possibilities and (2) the concrete approach of trying combinations unsystematically and incompletely.

4. Application of Proportional Reasoning and Separation of Variables (Equal Arm Balance - Inhelder and Piaget, 1958

The last task on the film, balancing the beam, requires students to apply proportional reasoning while separating the variables of weight and distance. There are twenty notches for hanging weights on each side of the fulcrum, with a mark at the tenth notch but no numbering. The weights provided are three, five, seven, and ten units made of the same washes as were used in the flexible rods task.

At the beginning of each interview, the student was shown the beam in balance, with ten unit weights at the distance of ten notches on each side of the arm. The following four tasks were then posted.

1. Use a 7-weight and a 3-weight to balance a 10-weight placed <u>ten</u> units from the fulcrum.

2. Use a 5-weight to balance a 10-weight placed at <u>ten</u> units from the fulcrum.

3. Use a 7-weight to balance a 10-weight placed <u>fourteen</u> units from the fulcrum.

4. Use a 7-weight to balance a 5-weight placed <u>seven</u> units from the fulcrum.

Students using concrete reasoning patterns have a general idea that increased distance on one arm compensates for increased weight on the other arm. They may reason qualitatively or use weight differences rather than ratios in all but the simplest cases of 2:1 comparisons. Formal reasoning patterns are in evidence when the more complicated weight comparisons in items 3 and 4 are treated by ratios.

Concluding Remarks

Our emphasis in this film and in the workshop is on the development of reasoning. Many other factors, such as motivation, interest and anxiety, also influence student performance. Even though we do not discuss these factors in detail, we have kept them in mind. The suggestions for teaching later on in this workshop can not only enhance reasoning, but may also increase motivation and allay anxiety.,

References

"Formal Reasoning Patterns," (1976) Davidson Films, 231 E. Street, Davis, CA 95616. Available as videocassette or 16mm film.

Inhelder, B. and Piaget, J., The Growth of Logical Thinking from Childhood to Adolescence, Basic Books, New York, 1958, Chapters 3, 7, and 11.

Karplus, E.F., Karplus, R., and W., "Intellectual Development Beyond Elementary School IV: Ratio, the Influence of Cognitive Style," School Science and Mathematics, Vol. 75, No. 6, October, 1974, pp. 476-482.