University of Nebraska - Lincoln
DigitalCommons@University of Nebraska - Lincoln

Module 2 - Concrete and Formal Reasoning

Workshop Materials - College Teaching and the Development of Reasoning

October 2007

MODULE 2 - CONCRETE AND FORMAL REASONING: Introduction

Follow this and additional works at: http://digitalcommons.unl.edu/adaptworkshopmodule2

Part of the Curriculum and Instruction Commons

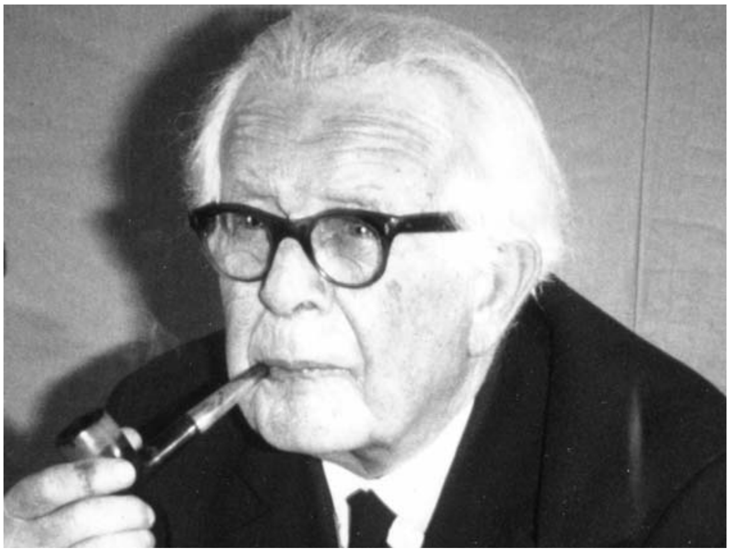
"MODULE 2 - CONCRETE AND FORMAL REASONING: Introduction" (2007). *Module 2 - Concrete and Formal Reasoning*. 1.
http://digitalcommons.unl.edu/adaptworkshopmodule2/1

This Article is brought to you for free and open access by the Workshop Materials - College Teaching and the Development of Reasoning at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Module 2 - Concrete and Formal Reasoning by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

MODULE 2

CONCRETE AND FORMAL REASONING

Introduction



Jean Piaget
(1895-1980)
Geneva, Switzerland
Figure 2-1

You have just responded to a few puzzles and examined responses of students answering these same puzzles. Observations of many children and adolescents attempting to perform similar tasks have led Jean Piaget and other psychologists to formulate theories concerning the mental processes individuals use to deal with problem situations. In this module, we shall introduce you to the idea of concrete and formal reasoning, a feature of Piaget's theory we consider important for college teachers. Modules 3 and 4 will give you more details and examples to illustrate what we say here. The later modules will introduce you to other important ideas in Piaget's theory and help you to apply these ideas to your college teaching.

Objectives

To enable you to identify and describe student behavior indicative of concrete and formal reasoning.

Procedure

Please begin by reading the essay, "Piaget's Theory in a Nutshell" included in the attached instructional materials. Then an activity is provided for you to re-analyze student responses to the puzzles in Module 1. Compare your ideas with others.

1. Essay Piaget's Theory in a Nutshell

In reading the student responses to the puzzles in Module 1, you undoubtedly recognized that type A answers were more complete, more consistent, and more systematic, in short, were better than type B answers. in fact, you may have been somewhat surprised to learn that many college students gave type B answers.

We suggest that each of the two types of answers demonstrates the use of either concrete or formal reasoning as described by the Swiss psychologist and epistemologist, Jean Piaget, in his theory of intellectual development. We shall, therefore, give you some general background regarding Piaget's theory and then apply it to the problems-solving and reasoning patterns used by students who responded to the puzzles in Module 1.

Dr. Piaget began his inquiry into the origins of human knowledge early in the 20th century. He sought to understand how knowledge develops in the human minds, i.e. to understand the genesis of knowledge. He called himself a genetic epistemologist to emphasize his interest in both the development of knowledge in the human species and by the development of knowledge by an individual. Dr. Piaget's life long work had several distinct phases as shown in Figure 2-1. From the large collection of Piaget's work we are only selecting a few concepts.

Three Periods of Piaget's Work

1922-29 - Started at Binet's Lab
- Began Semi-clinical interviews
- Discovered and described "Children's Philosophies" e.g. "Sun Follows Me" Egocentrism

1929 - 40 - Studied His Own Three Children
- Traced Origins of Child's Spontaneous Mental Growth to Infant Behavior e.g. Peek-a-Boo Conservation reasoning

1940-80 - Development of Logical Thought in Children and Adolescents
- Child's Construction of His World. Mind is not a passive mirror
- Child can reason about things but not about propositions.

Figure 2-2

The fundamental units of knowing, for Piaget, are schemes. A scheme is a class of physical or mental actions you can perform on the world. Notice, that in the Piagetian sense knowledge is better described as knowing, as an active process. Hence, we will often use the term reasoning to indicate the active, systematic process by which you come to know, or solve, something.

Two concepts of Piaget that we believe are most helpful to college teachers are:

• (1) **sequences or stages** in the development of schemes and

• (2) **self-regulation (equilibration).** Schemes develop gradually and sequentially and always from less effective to more effective levels. We shall discuss important schemes below.

The second key idea, self-regulation, refers to a process whereby an individual's reasoning advances from one level to the next. This advance in reasoning is always from a less to a more integrated and better adapted level. Piaget views this process of intellectual development as analogous to the differentiation and integration one sees in embryonic development. It is also seen as an adaptation analogous to the adaptation of evolving species. The process of self-regulation is discussed in a later module.

Piaget characterized human intellectual development in terms of four, sequential stages of reasoning. (See Figure 2-3).

Logical Knowledge
Stages of Cognitive Development
(Jean Piaget)

Stage	**Characteristics**	**Approximate Age Range (Years)**
Sensory - Motor	Pre-verbal Reasoning	0-2
Pre-operational	No cause and effect reasoning Uses verbal symbols, simple classifications, lacks conservation reasoning	1-8
Concrete Operational	Reasoning is logical but concrete rather than abstract	8- ?
Formal Operational	Hypothetical-deductive reasoning	11- (?)

Figure 2-3

The first two, called sensory-motor and pre-operational, are usually passed by the time a child is 7 or 8 years old. The last two, however, are of particular interest to college teachers; they are called the stages of concrete operational reasoning and of formal operational reasoning. What follows are some schemes that constitute important aspects of concrete reasoning and formal reasoning.

Concrete Schemes.

C1 Class inclusion. An individual uses simple classifications and generalizations (e.g. all dogs are animals, only some animals are dogs.)

C2 Conservation. An individual applies conservation reasoning (e.g. if nothing is added or taken away, the amount, number, length, weight, etc. remains the same even though the appearance differs).

C3 Serial Ordering. An individual arranges a set of objects or data in serial order and establishes a one-to-one correspondence (e.g. the youngest plants have the smallest leaves).

These basic reasoning patterns enable an individual to:

(a) use concepts and simple hypotheses that make a direct reference to familiar actions and objects, and can be explained in terms of simple association (e.g. the plants in this container are taller because they get more fertilizer);
(b) follow step-by-step instructions as in a recipe, provided each step is completely specified (e.g. can identify organisms with the use of a taxonomic key, or find an element in a chemical solution using a standard procedure);
(c) relate one's own viewpoint to that of another in a simple situation (e.g. a girl is aware that she is her sister's sister).

However, individuals whose schemes have not developed beyond the concrete stage have certain limitations in reasoning ability. These limitations are demonstrated as the individual:

(d) searches for and identifies some variables influencing a phenomenon, but does so unsystematically (e.g. investigates the effects of one variable but does not necessarily hold the others constant);
(e) makes observations and draws inferences from them, but does not consider all possibilities;
(f) responds to difficult problems by applying a related but not necessarily correct algorithm;
(g) processes information but is not spontaneously aware of his own reasoning (e.g. does not check his/her own conclusions against the given data or other experience).

The above characteristics typify concrete operational reasoning.

Formal Schemes:

F1 Combinatorial Reasoning: An individual systematically considers all possible relations of experimental or theoretical conditions, even though some may not be realized in nature (recall the Treasure Hunt Puzzle or Algae Puzzles).

F2 Separation and Control of Variables. In testing the validity of a relationship, an individual recognizes the necessity of taking into consideration all the known variables and designing a test that controls all variables but the one being investigated (e.g. in the Mealworm Puzzle, recognizes the inadequacy of the setup using Box 1).

F3 Proportional Reasoning. The individual recognizes and interprets relationships in situations described by observable or abstract variables (e.g. the rate of diffusion of a molecule through a semi-permeable membrane is inversely proportional to the square root of its molecular weight. Mr. Tall was six buttons tall and Mr. Short was 4 buttons tall, therefore, Mr. Tall must be one and a half times bigger than Mr. Short in any system of measurement.)

F4 Probabilistic Reasoning. An individual recognizes the fact that natural phenomena themselves are probabilistic in character, that any conclusions or explanatory model must involve probabilistic considerations, and that useful quantitative relationships can be derived, for example, the ratio of actual events to the total number possible (e.g. in the Frog Puzzle the ability to assess the probability of certain assumptions holding true such as: the frogs mingled thoroughly, no new frogs were born, the bands did not increase the death or predation rate of the banded frogs, and use of the ratio of 1 to 6).

F5 Correlational Reasoning. In spite of random fluctuations, an individual is able to recognize causes or relations in the phenomenon under study by comparing the number of confirming and disconfirming cases (.e.g to establish a correlation of say, blond hair with blue eyes and brunette hair with brown eyes, the number of blue-eyed blonds and brown-eyed brunettes minus the number of brown-eyed blonds and blue-eyed brunettes is compared to the total number of subjects).

These schemes, taken in concert, enable an individual to accept hypothesized statement (assumptions) as the starting point for reasoning about a situation. One is able to reason hypothetical-deductively. In other words, one is able to image all possible relations of factors, deduce the consequences of these relations, then empirically verify which of those consequences, in fact occurs. For example, in the Island Puzzle, such an individual could explain "If there were a plane route between Island A and C, then people could get from A to B but that is forbidden."

At the concrete operational stage, some formal schemes may be absent or they are only intuitively understood. Hence they are applied only in familiar situations and only partially and unsystematically. One can be said to be reasoning at the formal level when formal schemes have become explicit and useful as general problem-solving procedures. We consider the concrete/formal dichotomy a useful heuristic to guide us in our classroom activities. It is NOT a new system of pigeon holes into which you place students. They can serve as another perspective by which you can more clearly view the reasoning used by your students.

In the table on the next page, we summarize some differences between concrete and formal reasoning.

CHARACTERISTICS OF CONCRETE AND FORMAL REASONING

CONCRETE REASONING	**FORMAL REASONING**
Needs reference to familiar actions, objects, and observable properties.	Can reason with concepts, relationships, abstract properties, axioms, and theories; uses symbols to express ideas.
Uses concrete schemes C1-C3. Schemes F1-F5 are either not used, or used only partially, unsystematically, and only in familiar contexts.	Uses formal schemes F1-F5 as well as C1-C3.
Needs step-by-step instructions in a lengthy procedure.	Can plan a lengthy procedure given certain overall goals and resources.
Limited awareness of one's own reasoning. May be oblivious to inconsistencies among various statements one makes, or contradictions with other known facts.	Is aware and critical of one's own reasoning; actively checks conclusions by appealing to other known information.

Teachers who are interested in applying these ideas in their teaching should be aware that many theoretical and experimental issues relating to Piaget's work are still being investigated. Piaget's original notion was that all persons progress through the major stages in the same, invariant sequence, though not necessarily at the same rate. Recent studies suggest strongly that, although almost everyone becomes able to use concrete schemes, many people do not come to use the same formal schemes effectively

Piaget's research has been a very rich resource for ideas about the construction of knowledge. A number of scholars around the world, known by the label "constructivists", are continuing to study the implications of Piaget's epistemology for education and learning. For example, the original version of this essay was written by Dr. Robert Karplus, a physicist and science educator at the University of California-Berkeley, who developed an elementary school (K-65) science curriculum based on Piaget's ideas.

Since the above patterns of reasoning that have been described as formal represent extremely worthwhile educational aims and indeed are fundamental to developing meaningful understanding of theoretical and complex disciplines, the finding that many college students in this country do not effectively employ formal schemes on a great many content tasks presents a real challenge.

In addition to this finding, five further points regarding concrete and formal reasoning should be kept in mind by teachers:

• First, formal reasoning is more than this or that specific behavior. It is also an orientation towards approaching and attempting to solve problems. For this reason, a person who is confident and experienced in one area may reason hypothetico-deductively (formally) in that area, but may be unwilling to unable to generate hypotheses and reason flexibly in a threatening or unfamiliar area.

• Second, a person's ability to effectively deal with problems using formal knowing is really open-ended in that one may deepen and broaden one's understanding in a particular domain, and/or add new intellectual areas within which one can reason formally.

• Third, many persons demonstrate the use of reasoning patterns which seem to be a mixture of concrete and formal schemes when solving particular problems. This type of reasoning can perhaps best be termed transitional.

• Fourth, a person develops formal schemes from concrete schemes through the process of self-regulation. Concrete schemes involving class inclusion, serial ordering, and conservation about real objects, events, and situations are the valuable <u>prerequisites</u> for the development of formal schemes.

• Fifth, sometimes by applying memorized formulae, words or phrases, students can appear to be using formal schemes and/or be comprehending formal subject matter, when they are in fact not.

Although this essay has not touched on many aspects of Piagetian theory, we will briefly mention its major implications for college teaching. These ideas will be expanded upon in later modules.

The theory's main implications for college teaching are:

1. Reasoning is an active, constructing process that must engage your students in developing more adequate schemes.

2. Be aware that some of your students may sometimes use predominantly concrete schemes.

3. Be aware that many of the topics and concepts you teach require formal reasoning. You should figure out which topics these are.

4. Try to arrange your subject matter so it follows the developmental progression of familiar, concrete, real to less familiar, less concrete, and more theoretical.

5. Demonstrate to your students a questioning, dynamic, and active attitude towards the course you teach. Generate hypotheses, discuss alternative explanations and encourage your students to do the same. Turn your classroom into a laboratory where real problems are investigated and knowing is derived from acting on evidence that is produced. Rewarding this type of activity by your students helps students (i) realize that many hypotheses are constructed, (ii) reflect upon the meaning of hypotheses, (iii) examine

alternative hypotheses, (iv) examine evidence and its meaning, and (v) construct formal schemes.

2. Analysis of Student Responses in Module 1

Now we would like you to re-examine a few student responses to the puzzles from Module 1. This time, try to apply ideas from the essay "Piaget's Theory in a Nutshell" to classify these responses into the following more descriptive categories, rather than the A/B designation that we employed.,

PC = Pre-concrete, acausal, whatever

C = Concrete

Tr= Transitional (mixed concrete and formal characteristics)

F = Formal

? = Not possible to classify without more information

First select one student and reread and classify his or her responses to each of the puzzles. Record your classification of those responses thus making a "profile" of schemes used by this student. Follow this procedure for at least four students - more if you have time.

YOUR CLASSIFICATION OF STUDENT RESPONSES

	Scheme Classification			
Student (age)	Treasure Hunt	Short/Tall	Island	Mealworm
Delores Johnson (19)				
Barbara Downing (21)				
David Kenting (19)				
Harold O'Keefe (20)				
Norma Kuhn (20)				
John Blake (16)				

Now look at the results of your analysis. What can you conclude about the schemes any student may use at any time on any specific task?

Now ask for the Puzzle Analysis Handout. We have prepared a hand-out that gives a general analysis of responses to each puzzle, including the Frog Puzzle you may have given to some of your own students. We want you to identify the schemes students used in solving the Frog Puzzle and tally your results on the Frog Tally Wall Chart. If you have responses from your own students, please analyze them. If not, ask a workshop leader for a Frog Packet.