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Öğrenme Döngüsü Yaklaşımıyla İlköğretimde Fen Nasıl Öğretilmelidir?

Hakan Türkmen*

ÖZ. Bu çalışmanın amacı Piaget'nin zekâ modeli ışığında Öğrenme Döngüsü yaklaşımını bilimsel yayınlar ışığında açıklamaktır. Temel olarak "keşfetme", "terim tanıtma", ve "kavram uygulaması" gibi üç ana bölümden oluşan Öğrenme Döngüsü öğrenci-merkezli bir öğretim yaklaşımıdır. Türk eğitiminde sıklıkla kullanılan ders kitaplarına dayanan öğretim metodundan ziyade öğrencilerin deneyiminden gelişen bu Öğrenme Döngüsü yaklaşımı, tamamıyla diğer yöntemlerden farklı bir fen bilgisi öğretim yoludur. Bu çalışmada Öğrenme Döngüsü yaklaşımının "zihinsel çalışma modeli" ve "kavramsal gelişim" evrelerinden oluşan Piaget'nin zekâ modelinden nasıl türetildiği açıklanacaktır. Ayrıca eğitimin amacı ile Öğrenme Döngüsü yaklaşımının biri birini nasıl tamamladığı ve fen bilgisinin doğası ile nasıl örtüştüğü gösterilecektir. Öğrenme Döngüsü yaklaşımı bizim geleneksel fen bilgisi öğretim yöntemimizi değiştirecektir. Modern ülkeler seviyesini yakalamak için eğitimde gerekli olan yeniklerden birisi de, Öğrenme Döngüsü yaklaşımını fen bilgisi programına Türk kültürü ile karışımını sağlayıp en kısa zamanda bütünleştirmektir.
Anahtar Sözcükler: Öğrenme Döngüsü yaklaşımını, Fen bilgisi eğitimi, Piaget'nin Zekâ Modeli, Zihinsel Çalışma Modeli, Kavramsal Gelişim

ÖZET

***Amaç ve Önem**:* Gelişmekte olan ülkemizde, son yıllarda eğitimde yapılan değişikler Türk eğitim sisteminin yüzünü tamamen değiştirmiştir. Bu değişimde modern batı normları esas alınmıştır. Halen ülkemizde yeni yeni kullanılmaya başlanmış olan Öğrenme Döngüsü yaklaşımını daha iyi anlamaya çalışmak bu çalışmanın esas hedefidir. Bu hedef Piaget'nin zekâ modeli ışığında Öğrenme Döngüsü yaklaşımını bilimsel yayınlar ışığında açıklamaktır. Fen öğretiminde kullanılan yapılandırmacı (constructivism) yöntemin 5E veya 7E modellerinden daha farklı bir yaklaşımı içeren Öğrenme Döngüsü fen bilgisi eğitimcilerine yeni bir yaklaşım sunacaktır.
***Yöntem**:* Bu çalışmada Öğrenme Döngüsünün nasıl ortaya atıldığı ve tarihsel gelişimi yapılan aktif araştırmalar ışığında incelenmiştir. Derleme niteliğinde (historical research) olan bir çalışmadır.
***Bulgular**:* Yapılan araştırmalar sonucunda Öğrenme Döngüsü "keşfetme (exploration)," "terim tanıtma (term introduction)" ve "kavram uygulaması (concept application)" gibi üç ana bölümden oluşan öğrenci-merkezli bir öğretim yaklaşımıdır. Keşfetme (exploration) bölümünde öğrencilerin gözlemlerinden ve ölçmelerinden elde ettikleri verileri toplama ve kaydetmeyi içeren etkinlikler, deneyeler veya gezilerden oluşur. Bu bölümün asıl amacı öğrenciler kendi deneyimlerinden yola çıkarak öğrenmeleri teşvik etmektir. Öğretmen bu bölümde pasif bir roldedir, yapılacak olan deneyin, etkinliğin veya gezinin talimatlarını verir ve sonra öğrencilerini gözlemler ve dinler. Öğrencilerinin yaptıkları incelemeleri tekrarlamaları için öğrencilere sorular sorar ve onları düşünmeye, yorum yapmaya yöneltir. Amaç öğrencilerin sınıf arkadaşlarıyla diyalog kurmaları sağlama, yapılan etkinlikten tahminler yapma ve hipotezler kurmalarıdır. Terim Tanıtma (term introduction) bölümünde, öğrenciler kendi aralarında grup tartışmaları ile ve öğretmenin rehberliğinde yaptıkları deney, etkinlik ve gezilerden elde edilen veriler ışığında fen kavramlarını açıklamaları ve tanımlamaları beklenir. Kısaca kendi kelimeleriyle fen kavramları tanımlanır. Öğretmen, öğrencilerin yaptığı tanımlamaları sorduğu sorularla yönlendirir ve en son bilimsel

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tanımlamayı öğrencilerin kurduğu cümleler ile birlikte yaparak öğrencinin öğrenmesini sağlar. Amaç öğretilmek istenen fen kavramı öğrenci tarafından tanımlanmasıdır. Deney, etkinlik ve gezi sonucunda elde edilen bilgi gerçek hayatla bağlanmalıdır, yani öğrenciler verileri genelleyerek kendi yaşamlarıyla bağdaştırırlar. Üçüncü bölüm olan Kavram Uygulamasında (concept application), öğrencilerin fen kavramlarını araştırmalarını ve bunları kullanmaları beklenir. Bunun içinde ekstra deneyler, okumalar, film ve tartışmalar yapılmalıdır. Tanımlanan kavram bilgisi farklı kaynaklar kullanılarak daha da genişletilir. Böylece öğrenciler kavramların diğer alanlardaki anlamları görerek dünya gerçekleri ile kavramlar arasında ilişki kurmaya çalışırlar.

Üç bölümden oluşan Öğrenme Döngüsü fen bilgisi programına entegre edilmeli ve ilköğretimin her safhasında kullanılmalıdır. Bu sayede öğrencilerimiz bilimsel verileri değerlendirme ve yorumlama bilgisine kavuşacaklardır. Davis ve Falba'ya (2002) göre, Öğrenme Döngüsünde öğretmenin rolü işbirliği yaparak (collaborative ve cooperative), yapılandırmacı (constructivist) ve diğer öğrenim metotları tarafından desteklenen ve düşünmeye sevk eden çalışma kâğıtları, günlük yaşamlarında karşılaştıkları sorunları keşfetme ve anlamlı çözümler üretmeyi esas alan sosyal ve mantıksal bir eğitim ortamı oluşturmaktır.

Piaget, öğrenmeyi yaşa bağlı bir süreç olarak kabul eden 4 dönemden oluşan Kavramsal Gelişim (cognitive development) modeline göre açıklamıştır. Zihinsel çalışma modeli doğumdan başlayan ve yetişkinliğe kadar devam eden dört dönemde değerlendirmiştir. Dönemler arasında geçişler keskin sınırlar içermemekle birlikte, dönemler ilerledikçe bireyin kavrama ve problem çözme yeteneklerinde niteliksel gelişmeler gözlenmektedir. Bu dönemler Duyusal Devinim (Sensory motor) dönemi, İşlem Öncesi (Pre-operational) dönem, Somut İşlemler (Concrete Operational) dönemi, Soyut İşlemler (Formal Operational) dönemidir. Her dönem öğretmen için önemlidir çünkü öğrencilerinin bireysel farklılıklarını bilişsel gelişim açısından dikkate almalı ve öğrencilerden bilişsel gelişim düzeylerine göre etkinlikler yapılmalıdır. Bireyin bir dönemden diğer bir döneme geçerken 4 ana faktörün etkili olduğunu belirtmiştir. Bu faktörler (1) Olgunlaşma (*Maturation)*; bireyin fizyolojik bir büyümedir, (2) Deneyim (*Experience)*; bireyin geçmişte yaşadığı deneyimlerdir, (3) Sosyal geçiş veya iletişim (*Social Transmission);* bireyin içinde bulunduğu toplumun kültürüdür, ayrıca okullar arası, mahalleler arası, inançsal vb farklılıklarda bu kültürün parçasıdır. Birey farklı kültürlerde farklı gelişimler gösterir, (4) Dengesizlik (*Disequilibrium)*; bireyin anladığı ile karşılaştığı arasındaki denge bozukluğudur. Bu bozukluğu öğretmen fen dersinde yaratabilirse öğrencilerin öğrenmesine ve böylece büyüme ve gelişmesine neden olur (Bybee & Sund, 1990).

Özümseme (assimilation), İntibak (accommodation), Adaptasyon (adaptation) ve Organize etme (organization) fazlarından oluşan Piaget'nin Zihinsel Çalışma Modeli Öğrenme Döngüsü ile iç içedir. Öğrenme Döngüsünün Keşfetme bölümü yapılan etkinliklerle yeni bilginin Özümsenmesini sağlar (Renner, Abraham, & Birnie, 1986), ve bu dönemde dengesizlik (disequilibrium) başlar. Terim Tanıtma bölümünde, birey kavram ile ilgili kendi tanımını yapar, bunu yapması içinde eski tecrübelerin ışığı altında yapmış olduğu etkinliklerden yararlanarak yeni bilgiyi özümser. Genellikle özümseme sınıf içindeki bireyler arası veya gruplar arası tartışmalar sonucu oluşur. Kavram Uygulama bölümünde, yapılan ekstra deneyler, etkinlikler ve geziler sonucunda yeni bilgi genişletilir, uygulama alanları büyür, gerçek hayatla bağdaşır. Birey yeni bilgiyi kendi hayatına adapte eder ve böylece organize bir şekilde hayatında kullanmaya başlar. Tüm elde edilen bulgular, modern ülkelerin eğitim standartlarıyla uyumlu olduğunu göstermiştir. Bireye bilgi aktarımı değil, bilimsel süreç ve üstün beceriler kazandırma esas alındığı bulunmuştur.

Tartışma ve sonuç*:* Öğrenme Döngüsü yaklaşımı bizim geleneksel fen bilgisi öğretim yöntemimizi değiştirecektir. Modern ülkeler seviyesini yakalamak için eğitimde gerekli olan yeniklerden birisi de, Öğrenme Döngüsü yaklaşımını fen bilgisi programına Türk kültürü ile karışımını sağlayıp en kısa zamanda entegre etmektir.

How should science be taught by using learning cycle approach in elementary schools?

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ABSTRACT. The purpose of this study is to explain "Learning Cycle" approach in the light of Piagetian Model of Intelligence. Basically, Learning Cycle, which consists of three essential phases, exploration, term introduction, and concept application, is a student-centered teaching procedure. This Learning Cycle approach is a totally different way of teaching science which comes from students' experiences, rather than through other learning methods relying on the textbook, which is generally being used in Turkish education. I will explain how derived learning cycle approach from the work of Piaget's theory, which consist of Model of Mental Functioning and Stages of Cognitive Development. I will also show how the Learning Cycle approach covers purpose of education and nature of science. Learning Cycle is going to change our traditional method of teaching science. To catch up modern western civilization in the field of education, somehow we should integrate Learning Cycle approach, which is one of innovations in education, in our science curriculum as soon as possible.
Key Words: Learning Cycle Approach, Science Education, Piaget's Model of Intelligence, Mental Functioning, Cognitive Development

INTRODUCTION

Philosophers of science produce to account for the process of representation of reality. Theory based science education assumes that theories are at the top of the scientific hierarchy. More than a decade ago, Renner and Marek (1990) asserted that theory based science education "must include educational purpose, discipline of science and a model for learning" (p. 241). The *Learning Cycle* is a teaching procedure that 1) parallels the nature of science, 2) applies the educational standards, and 3) translates a model of cognitive development. In this article, it will be explained the learning cycle approach in the light of Piagetian Model of Intelligence. It will be discussed that how the learning cycle approach covers central purpose of education and nature of science.

Literature Review

During the last a few decades, there have been many efforts to increase students' learning abilities and to reform teaching and learning practices in science classrooms. The Learning Cycle that introduced by Karplus and Thier (1967), has evolved into one of the most important teaching approaches in science education. Marek, Eubanks, and Gallaher, (1990) described science "is a process of investigation through which an understanding of scientific, facts, laws, principles, and theories is gained" (p. 821). French Mathematician Poincaré cited "science is built up with facts as a house is built with stones, but a collection of facts is no more a science than heap of stones is house" (Marek, Eubanks, & Gallaher, 1990, p. 822). In the light of these descriptions, Renner and Marek (1990) said that learning cycle is an inquiry based teaching approach. Inquiry can be defined a search for information, a quest for knowledge, or an exploration of certain phenomena to understand the world better (Marek & Cavallo, 1997). The National Research Council defined inquiry as a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories (National Research Council, 1996). The critical element of inquiry is that student seeks answers to questions and is not given

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answers. True learning comes from the investigation, resulting in summarizing, evaluating, and communication findings and examination for known facts and theories; this is the essence of inquiry (Hogan & Berkowitz, 2000; McKinnon & Renner, 1971). People continue the process of inquiry from the time they are born until they die. Infants begin to make sense of the world by inquiring. From birth, babies observe faces that come near, grasp objects, and put things in their mouths. The process of inquiring begins with gathering information and data through applying the human senses, seeing, hearing, touching, tasting, and smelling (Colburn, 2000; Lawson, 2000; Martin-Hansen, 2002). Unfortunately, our traditional educational system has worked in a way that discourages the natural process of inquiry. Students become less prone to ask questions as they move through the grade levels. In traditional schools, students learn not to ask too many questions, instead to listen and repeat the expected answers. Some of the discouragement of our natural inquiry process may come from a lack of understanding about the nature of inquiry-based learning.

Joyce, Weil, and Calhoun (2000) claimed that there is a probability which the student will acquire a particular performance based on types of learning in the models of teaching. In the light of this description Learning Cycle is not a method or a model of teaching, which allows for many methods of teaching (e.g., laboratory experiments, questioning strategies, demonstrations, group work, field trips, the use of modern technologies), because Marek, Laubach, and Pedersen, (2003) stated that "the learning cycle is a specific organization of phases dominated by the integrity of the whole and the relationships of the phases to each other for experiencing science by inquiry and for organizing science curricula" (p. 148). This approach is a student-centered teaching procedure and offers an another way of teaching science concepts in with students learn from their experiences, rather than through other learning methods relying on the textbook for classroom learning (Fleener & Marek,1992; Gerber, Marek, & Cavallo, 2001b). Basically, learning cycle consists of three essential phases;

Exploration: This phase typically consists of a hands-on activity or field experience in which students gather and record data from their observations and measurements. The main purpose of this phase is that students are encouraged to learn through their own experience. When a teacher introduces a child to the materials or experience through a discussion session in which the child will begin to discover the science concept through his or her questions. Students should be encouraged to dialogue with classmates or teammates to formulate explanations, and to make predictions. This phase makes available to the groups the experience for each individual. This stage involves finding out what happened within the individual during the experiment (Beisenherz, Dantonio, & Richardson, 2001; Lawson, 1999, 2001).

Term introduction: The teacher takes an active role in leading the students to develop the concept. Students use their experience from exploration phase to develop an understanding of the science concept and explain the science concept with guidance from the teacher. During this phase, students make their own meaning out of the observations. Students are encouraged to formulate relationships which generalize their ideas and experiences. The role of teacher is to be mediator in assisting students to formulate these relationships and introduce the scientific term. This phase makes the experience practical, if it is omitted or glossed over the learning is likely to be superficial. Crucial thing of this phase is to move reality from inside the experience to the reality of everyday. In other word, students are led to generalize their new awareness on situations in the personal or work life.

Concept application: It provides opportunities to directly apply the concept learned during the term introduction phase. There can be done additional experiment, reading, film, and discussion. Children continue to expand the concept by conducting more activities and using additional resources for investigation. Piaget (1952) described this phase "putting new thoughts in accord with previous thoughts" (p. 8). During this time, the teacher should make an assessment of the students' abilities and thinking habits in investigating science ideas. Students perform experiments that are explained by term introduction, and in this phase, new unexplained phenomena arise. The main propose is to connect the newly learned concept to previously learned concept (Abraham, & Renner, 1986; Fleener & Marek, 1992**;** Gerber, Marek, & Cavallo, 2001b; Lawson, 1999, 2000, 2001; Lawson, Abraham, & Renner, 1989; Marek & Bryant, 1991; Marek & Cavallo, 1997; Renner, Abraham, & Birnie, 1985).

In traditional teaching methods, teachers give science concept (informed) then give the exercises related to the concept (verify) and then let their students do lab activity (practice) and laboratory activities are more peripheral to the main focus of instruction because they are used to confirm the concept (Abraham, & Renner, 1986**;** Renner, 1982; Renner, Abraham, & Birnie, 1985). Learning cycle is totally opposite way of traditional teaching method because teachers do not give any theoretical information before starting the laboratory activities. Students are instructed to collect data and then try to get concept by their own knowledge (Abraham, 1982**;** Renner, Abraham, & Birnie, 1985). In other words, explanation and investigation of concept, which is the use of evidence to back up conclusions, and the designing of experiments, are emphasized in learning cycle approach. Whereas the development of skills and techniques that are the receiving of information, and the knowing of the outcome of an experiment before doing it, is emphasized in traditional teaching method (Abraham, 1998). Since 1975, many researchers compared the learning cycle with traditional approaches. According to many studies (Abraham, 1982; Lawson & Renner, 1975; Purser & Renner, 1983; Renner, 1982**;** Renner, Abraham, & Birnie, 1985; Schneider & Renner, 1980), the learning cycle approach is better way to teach science than the traditional methods because "students feels more secure, and believe they have learned more if they experienced it" (Renner, Abraham, & Birnie, 1985, p. 323) and learning cycle teachers spend up to %90 of class time actively involved with their students, whereas traditional methods of teachers approximately spend %7 (Marek & Methven, 1991).

The three phases should be reinforced throughout the science curriculum and should be taught in context at every grade level, in nearly every unit. Teachers should identify the potential hazards and/or precautions involved in scientific investigations and use simple key to classify objects and/or phenomena. Students must learn to evaluate conclusions based on scientific data. Teacher's main role is in learning cycle approach creating social and intellectual climates, where collaborative, cooperative, constructivist and other learning methods are supported in this approach and providing contexts for students to think critically, explore phenomena in their everyday lives, and solve meaningful problems (Davis & Falba, 2002).

The Nature of the Learner

How derived learning cycle approach from the work of Jean Piaget Piaget's theory. Piaget's theory has two major parts, "Stages of Cognitive Development" that predicts what children can and cannot understand at different ages and "Model of Mental Functioning". Piaget contributed very much to our understanding of learning and development in children. His theory of learning is a cornerstone of contemporary state of understanding how humans learn. Piaget stated that cognitive thought develops in four qualitatively different stages (Piaget, 1964). Each stage represents a different mode from which we view our world. Piaget's four stages are:

First, the *sensorimotor* state (0-2 years), the child is predominately concrete and active in his learning style. Yet the child has few schemes or theories into which he can assimilate events, and as a result, his primary stance toward the world is accommodative. Intelligent action is motoric, which is reflex action. Environment plays a major role in shaping his ideas and intentions (out of sight, out of mind). Learning occurs primarily through the association between stimulus and response. There is a cliché a word of sensorimotor stage "out of sight, out of mind".

Second, the *preoperational* stage (3-7 years), children cannot mentally represent what they can do in action. Child's thought emerges but it is pre-logical and is intuitive. Child often relies on animistic, belief that everything has a soul in nature, and anthropomorphic, having human characteristics or attributes, explanations of nature events. At this stage, the child's primary stance toward the world is divergent. He is captivated with his ability to collect images and to view the world from different perspective. This stage's cliché words are "see / decide / report".

Third, the *concrete operational* stage (8-11 years), the intensive development of abstract symbolic powers begins. Learning is governed by the logic of classes and relations. In this stage, child increases his independence from his immediate experiential world through the development of inductive powers. He relies on concepts to select and give shape to his experiences.

The final stage is *formal operational* stage (12- up years), the adolescence moves from symbolic processes based on concrete operations to the symbolic processes of representational logic. His thinking involves abstractions and hypothetical-deductive reasoning. He develops the possible implication of his theories and proceeds to experimentally test which of these are true (Bybee & Sund, 1990). To know each stage is very important for teacher because teachers can see the world via our students' eyes and understand how our students should be taught the concept.

In Marek and Renner's research (1972), 65% high school students who enrolled in his biology classes were in concrete operational stage. That means teachers have students in both concrete operational and formal operational levels (Marek (1975).

Consequently, diagnosis of what stage our students in has to be undertaken by teachers to help them identify students' needs and then teach easily. So we, as teachers, will able to maintain the development of cognitive skills as the central goal of our instruction and design a curriculum that allows our students to develop their process skills.

Basically;

Concrete operational students	Formal operational students
• require objects, events, or actions for logical reasoning • are unaware of inconsistencies and mistakes in reasoning • need clear, sequential directions for long and detailed projects. • conservation, class inclusion, ordering, and reversibility are characteristic reasoning patter. • They can solve easily quantity, weight, and volume of substance problems	• can reason abstractly without reference to concrete objects, events, actions. • aware of inconsistencies and mistakes due to the use of mental check and balances (reflective thought) • can establish their own plans for long and detailed projects if given aims and goals. • Theoretical, hypothetical reasoning patterns are characteristic.

The question is how child moves from his stage to another stage? Piaget listed four important factors that contribute to movement from stage to stage.

1. *Maturation*: Maturation is physiological growth of organism. Maturation of the nervous system gives us the opportunity to see, hear, and touch…etc to experience in our environment.

2. *Experience*: Students past concrete experience and the ability to recall these experiences are critical for further development. Piaget outlined two types of experiences:

a- Physical experience: drawn directly from objects. It includes simply actions engaging all manner activities that allow students to gather data about physical environment.

b- Logical-mathematical experience: drawn by actions which affect objects. Piaget said that knowledge is not drawn from objects but it is drawn by actions effected upon the object.

Experience requires mental operations and has to do with logic and order of the environment. Discouraging children from feeling, touching, and interacting with environment in the classroom deprives them of the needed physical experience that leads to mental development.

3. *Social Transmission*: means to pass along what your own society is like. Most common social transmission is oral language, talking. Also social transmissions occur through the institutions of society, schools, church, and museums. The interaction concept is so important to us that we use social interaction as a synonym for social transmission.

4. *Disequilibrium*: an imbalance between what is understood and what is encountered. People naturally try to reduce such imbalances by using on the stimuli that cause the disequilibrium and developing new schemes or adapting old ones until equilibrium is restored. According to Piaget, learning depends on this process. When equilibrium is upset, children have the opportunity to grow and develop (as cited by Bybee & Sund, 1990).

<u>The Theory Base of School Science</u>

People's knowledge of the world is improved through the continuous mental adaptation to physical changes and environmental encounters, physical of maturation, natural experiences, and formal education. Piaget proposed that two basic principles, which are "organization" and "adaptation", guide children's intellectual development. As children mature, their knowledge are integrated and reorganized into more complex systems that are better adapted to their environment. Adaptation of knowledge occurs through the process of "assimilation" and "accommodation". According to Piaget, there are mental structures or schemes, which are mental systems or categories of perception and experience that determine how data or new information is perceived. Mental structure explains how a person learns, no matter what developmental stages a person is in (Bybee & Sund, 1990). The experiences, which influence a student's interpretation of stimuli, are content. Content is not meaningful to the student until it has been transformed by this student's mental structures. However, data that are obtained always cannot be transformed by his or her mental structures. Mental functioning is the process that occurs for changes in the cognitive structure. Mental functions do not change during development. They are functional invariants. Phase of *assimilation* refers to the process of fitting someone's external reality to his or her existing cognitive structure. For example, the first time many children see a skunk, they call it a "kitty" (Gredler, 1997). They try to match the new experience with an existing scheme for identifying animals. When a child is confronted with a new stimulus, the child tries to assimilate it into existing schemata. Sometimes this is not possible. Sometimes a stimulus cannot be assimilated, because there are no schemata in which it readily fits. Piaget explains about assimilation:

"Intelligence is assimilation to the extent that it incorporates all the given data of experience within its framework. Whether it is a question of thought which, due to judgment, brings the new into the known and thus reduces the universe to its own terms or whether it is a question of sensorimotor intelligence which also structures things perceived by bringing them into its schemata, in every case intellectual adaptation involves an element of assimilation, that is to say of structuring through incorporation of external reality into forms due to the subject's activity" (Piaget, 1952, p. 6).

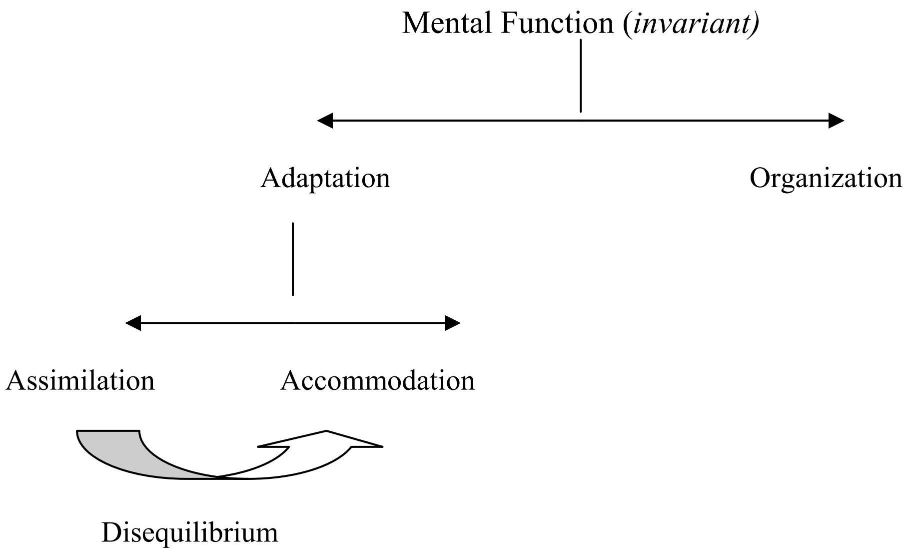
Piaget emphasized the functional quality of assimilation where children and adults tend to apply any mental structures that are available in order to assimilate a new event occurs all of the time and this is the most common form of learning in education. If the new data don't make sense to the existing mental structure, then the new information is incorporated into a new structure. Piaget calls this mental function, *accommodation*. According to him;

"There can be no doubt either, that mental life is also accommodation to the environment. Assimilation can never be pure because by incorporating new elements into its earlier schemata the intelligence constantly modifies the latter in order to adjust them to new elements. Conversely, things are never known by themselves, since this work of accommodation is only possible as a function of the inverse process of assimilation" (Piaget, 1952 p. 6, 7).

Accommodation takes place every time we are confronted with a new stimulus. Accommodation refers to the process of changing internal mental structures to provide consistency with external reality. When the existing schemas must be modified or the new schemas are created to account for a new experience, accommodation occurs. For example, baby, who is in the sensorimotor period, uses sense and motor abilities such as sucking, grabbing, holding, to understand the world. When he comes across the new object, such as phone machine, he will try his old schemata grab, suck, and trust himself. So the schemata will adapt to the new object. Accommodation obviously influences assimilation. Assimilation is the action of learning to identify, recognize, and generalize objects but accommodation is the modification of the action of assimilation. Thus, reality must be assimilated, and structures must be accommodated. After acquiring new concept, assimilation and accommodation are together part of mental functioning model called *adaptation.* Assimilation causes *disequilibrium*. Disequilibrium will lead to accommodation. Piaget states that *equilibration* is the basis for acquiring knowledge. When a structure changes from one state to another is equilibration. Equilibration is the search for mental balance between cognitive schemes and information from the environment. If we confronted with a new event, and our existing schemata works, then equilibrium exists. If the scheme does not produce a satisfying result, then disequilibrium exists, and we become uncomfortable. This means, if the experience is totally unrelated to what we already know, we cannot accommodate it, therefore, we would be in a state of disequilibrium. Piaget states that we acquire information through the processes of assimilation and accommodation and then the acquired information is organized. Piaget described as "putting thought in accord with thought (Piaget, 1952, p. 8). The basic definition for *organization* is the relationships that exist between a new mental structure and previous mental structures (Abraham & Renner, 1986; Bybee & Sund, 1990; Renner, Abraham, & Birnie, 1986). Piaget's mental functions are invariant in all ages.

The main point is how we connect the Piaget's mental functions with learning cycle approach. This three-phase learning cycle directly corresponds to the Piagetian principles of assimilation, accommodation, and organization.

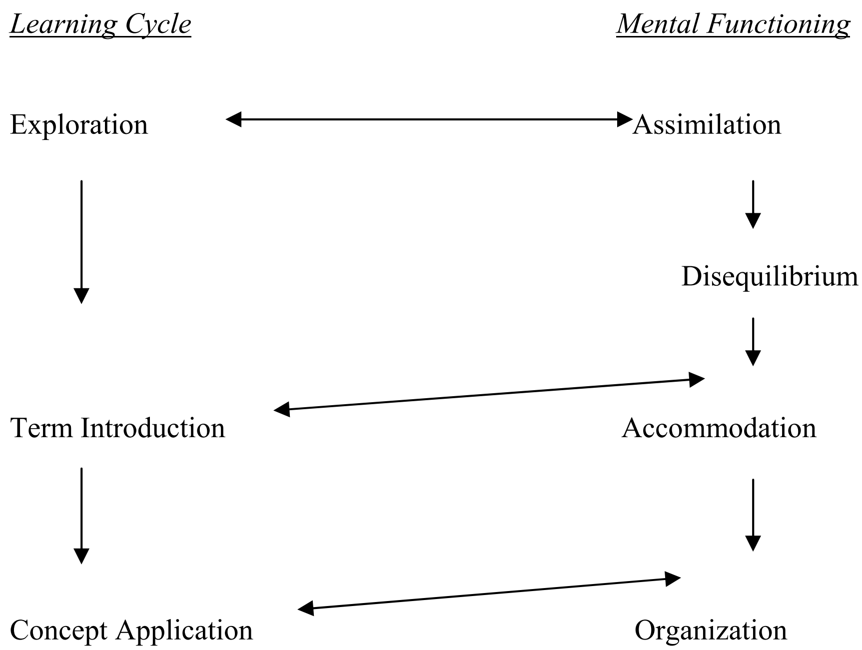
"Exploration phase of learning cycle provides experiences leading assimilation and disequilibrium" (Renner, Abraham, & Birnie, 1986, p. 633), because, when information is received from the outside world, which is too far away from the mental structure, the students does not make enough sense that rejecting in their mind, and the students should be in a state of disequilibrium, or if the information fits the external reality to their existing cognitive structure, they can easily assimilate in their mind. That is students are in the equilibrium phase. The exploration phase has the students interact with the laboratory environment while collecting data formally or informally. Marek, Eubanks, and Gallaher (1990) pointed out that here "students . . . have experienced or assimilated the essence of the concept. The experience is more directed than in the pure discovery approach, but care is taken not to tell the student what data is neither to be used in developing the desired concept nor to ask the student to interpret data prematurely” (p. 832). Activities and materials are supplied by teacher and the role of teacher is just encouraging students and gives them some suggestions to maintain an appropriate level of disequilibrium.



Term introduction phase of the learning cycle is when students are expected to accommodate the new ideas. The teacher takes an active role in presenting the concept. Students redefine, change, or invent mental structures at this point. Students will be in the accommodation phase in this learning cycle stage, because students make their own meaning out of the observations. Either they succeed to make adjustments in each mental structure to make it fit their experience, or they do not construct the new mental structure and then fall in the disequilibrium phase again. In other words, in this stage, if the students deal with the disequilibration the activity, they would accommodate the concept. Generally, accommodation phase will occur during the class discussion.

In the concept application stage, children continue to expand the concept by conducting more activities and using additional resources for investigation. The expansion of the idea may involve “additional laboratory experiences, demonstrations, readings, questions, and/or problem sets” (Marek, Eubanks, & Gallaher, 1990, p. 831). Concept application matches to the organization phase in the Piaget’s mental functioning. This phase allows additional time for accommodation required by students needing more time for equilibrium. It also provides additional equilibrating experiences for students who have already accommodated the concepts, which were introduced. Its intent is to aid the organization and generalization of knowledge by adjustment of related mental structures and transfer from one context to another.

There are two key Piagetian implications for teaching and learning. First, learning is an active process where direct experience, making errors, and looking for solutions are vital for assimilation and accommodation of information. How information is presented is important. When information is introduced as an aid to problem solving, it functions as a tool rather than an isolated arbitrary fact. Second, learning should be whole, authentic, and real. In a Piagetian classroom there is less emphasis on directly teaching specific skills and more emphasis on learning in a meaningful context (MacKinnon, 2002).



Piaget believed that people must first organize their thoughts and then adapt their thinking to include new ideas, as new experiences provide additional knowledge. In the light of these factors, school experiences can accelerate the movement of children from the preoperational to concrete and from concrete to formal. Our position, as teachers, is to create positive experience for children to accelerate their capacity. First of all, learning is not repeating something, they understand it. Learning implies meaningful understanding. Also, we cannot know how children learn. We make judgments about how children learn by observing how they act when exposed to a given objects, event, or situation. We have constructed all of our understanding for ourselves. From birth to death, we are knowledge constructors. No one can give us our understanding, we have to do ourselves. Knowledge building in children and adults follows the same pattern because both are based on the same tools, that is, the same theory applies to each. Children and adults construct knowledge that is fundamentally the same, thus, the patterns we find in their respective development of knowledge must be the same. What is different is the nature of the knowledge that is constructed. Children replicate the adult construction of physical artifacts; they make pictures, build block buildings, dress up, cook pretend food, dig ditches in the sand, carve shapes in clay, and invent all kinds of things that mimic our adult creations. But they do not create the kinds of wonderful, complex, and profoundly beautiful artifacts that adults do. They may build knowledge artifacts out of the same kinds of tools, but they do not build the same qualities of knowledge. They do not have the patience, maturity, or skills to do so. It is no different for conceptual artifacts than it is for physical artifacts, the tools and the types are the same, but the results are different. Children seem to have natural mental maturations at Piaget's key ages, and if our society has enabling entities, they naturally jump to the next step. Indeed, if we were to analyze the development of knowledge in children more carefully, we would actually find the same pattern of phases we found in historical knowledge.

Mental functioning aspect of the model is the method behind the phases of the learning cycle. Cognitive development is a complex process with four main concepts affecting the development process. All of the four concepts associate with the formation of schemata and modification of the schemata to attain a balanced understanding of the external world. If we think how to use the Piaget’s cognitive development in our schools, as an educator, we must plan a developmentally proper curriculum that enhances our students' logical and conceptual growth. Classrooms should be filled with opportunities students find challenging. The expansion of the idea in the phase of the learning cycle is derived from organization.

Briefly, Piaget's theory inspired major curriculum reforms, and it had important effects on education practice today. Among Piaget's major contributions to education are that knowledge must be constructed by children; educators should help children learn how to learn; learning activities should be matched to the children's level of conceptual development; and peer interactions play an important role in the child's cognitive development. Piaget's theory also emphasizes the role of teachers in the learning process as organizers, collaborators, stimulators, and guides.

<u>The Goals of Science Education and the Nature of Science</u>

The learning cycle teaching approach should be examined within the contexts of the nature of science and the purpose of education. Science is our way to observe, understand, and explain the operation of the universe and of the living things it contains, because a scientific theory has to be examined through by repeatable observations. In addition to giving us the basic information that we need to make sense of the natural world, the science teaches us to identify and examine our suppositions with our powers of analysis, as well as to expand our capacity. The nature of science should be examined from many perspectives within the elementary through high school levels. However, a serious problem is that the traditional teaching method utilized by many teachers that is teaching as only information-givers to passive students, appears outdated. Many studies have shown us that only 20% of the students retain what the instructor discussed after the lecture (Zahorik, 1995). That means that students who have memorized facts, principles, or any specific kind of knowledge without experiencing and developing concepts for themselves have not been taught science. In that perspective and results, learning cycle approach is the best solution because teachers using learning cycle in their science classrooms let their students try to experiment and develop concepts for themselves.

In the other way, learning cycle approach fulfills the central purpose of education. Science education teachers need to use information from primary sources, which are those that we experience directly from observation, or experimentation. On the other hand, the objective of Turkish education, according to Basic Law No. 1739 for National Education, is to educate individuals who:

- adopt the values of the Turkish nation,
- know the duties and responsibilities to their country and have made them a part of their behavior,
- can produce knowledge, can utilize the knowledge and technology produced, and
- are democratic citizens and respect human rights (Ministry of National Education, 1999).

As a result of these concerns, the development of the ability to think should add into the objective of Turkish education. That means that the central purpose of education should be to teach students how to think. Also students needed to develop "ten rational powers", which enable persons to apply logic and available evidence to their thoughts, and attitudes, as well as to follow their individual goals for on central purpose of education (Educational Policies Commission of the National Education Association, 1961). Ten rational powers are recalling and imagining; classifying and generalizing; comparing and evaluating; analyzing and synthesizing; and deducing and inferring. These ten rational powers are described as follows. The first is recalling, which is the ability to retrieve information. We use this power to pass ideas on to someone or to achieve new ideas. There is no thinking without the power to recall. Next is comparing, which can be used for producing information about science or an event. Inferring may be used immediately after gathering data. Inferring is the explanation of only one action, event, or observation within a larger collection of actions or events. After inferring, it is useful or necessary to generalize, which is expanding the inferences. Also, the power of generalizing includes hypothesizing. Deducing helps we make sense of new events. It is like solving a puzzle. Another important skill is classifying. This is the systemic arrangement of events or data. In addition, classifying makes the use of other rational powers easier. Analyzing is also valuable. To analyze is to examine knowledge to understand what it is and what it means. It is an important skill for developing higher reasoning and logic. Along with rational powers that help us look at data, imagination is crucial. It should be used by individuals for creating models, drawing pictures, or presenting opinions about new things in a variety of ways. Next, it is important to be able to synthesize. Synthesizing is gathering separate things together to make a meaningful whole. This power links to the rational power of imaging to produce a model. Finally, an individual needs the power to evaluate, that is, it is to make a judgment about an event, or observable situation.

Learning cycle approach is to contribute to the achievement of the purpose of education because science teacher who uses learning cycle approach in his science class lead students to use the rational powers (Marek & Cavallo, 1997). It is obvious that learning cycle approach and purpose of education, ability to think, and all objectives connected each other. For example, in exploration phase of learning cycle, students start to assimilate new schemata, result by using classifying and students have to make a through analysis of the data resulting from their exploration. In term introduction, synthesis is incorporating the use of imagination and also comparing, evaluating, and inferring are necessary to understand the concept. In the concept application, after understanding the new concept students start to reorganize their new and old concepts and generalize them; deducing rational power is used in whole concept application phase. Overall, the instructional strategy relates the nature of science and the purpose of education to the learning cycle.

CONCLUSION

We can change our traditional way of teaching science, if only teachers' beliefs about teaching, learning and the nature of science can affect their practice (Hogan & Berkowitz, 2000). Learning cycle which is based on inquiry-oriented teaching is not a new science education concept. This method is moving from a teacher-initiated method to a student-generated or student-guided method with teacher as facilitator. Children of all ages can be successful at inquiry and inquiry can be practiced outdoors, indoors and in a wide variety of content areas. I think this diversity is enriching to us all (Ash, Greene, & Austin, 2000).

The learning cycle displays a reflection on the nature of science in its emphasis on discovery of knowledge. The learning cycle allows students to develop new concepts in the nature of knowledge. Each phase of the learning cycle enhances the development of students' capacity to think through the use and expansion of the ten rational powers. If we compare the learning cycle to some other teaching strategies, we can see that the learning cycle is easy for teachers to use. All stages of the learning cycle lend themselves to cooperative learning, especially exploration and concept application. However, the teacher will need to devote more time to preparation of materials. Teacher should have a strong content background to provide suitable reinforcement during exploration and concept application. According to Stepans, Dyche and Beiswenger (1988) "...the lecture-recitation form of science teaching can, at times, confuse students about abstract concepts, and the memorization of terms, facts, and formulas does not result in real learning when students are concrete operational" (p. 190). The learning cycle is an effective tool for teaching science, which promotes the rational development of students while allowing them to understand science's inherent characteristics.

In reality, although many of teacher who implement the learning cycle for first time may have trouble, some studies showed that "learning cycle teaching approach is difficult, complex and abstract structure to understand" (Marek, Laubach, &Pedersen, 2003. p. 156), many articles indicated that learning cycle improves teacher behavior and students outcomes, that is, learning cycle is an effective teaching approach (Abraham, 1982; Cavallo & Laubach, 2001; Gerber, Marek, & Cavallo, 2001b; Marek& Cavallo, 1995; Marek, Eubank, & Gallaher, 1990; Marek & Methven, 1991; Odom & Kelly, 2001; Renner & Marek, 1990; Rosenthal, 1993; Settlage, 2000) and using learning cycle approach in classroom has more positive attitudes toward science and science instruction than other approaches (Lawson, Abraham, & Renner, 1989). However, Turkish students often do not experience these kinds of activities until graduate school. In teacher-directed methods teacher can teach science and students might enjoy science but, without a great deal of critical thought (Marrero, 2000). Somehow we need to put learning cycle approach in our science curriculum as blended with Turkish culture.

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