CHAPTER II

CONCEPTUAL FRAMEWORK

2.0 Introduction

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2.0 INTRODUCTION

Science teachers continuously strive to improve their instructional practices to enhance student learning. Complementing the aims of science teachers, curriculum developers systematically attempt to identify research findings, which they try to incorporate in materials that will facilitate connections between the teachers, the curriculum, and the students. Recently, the use of coordinated and coherent sequencing of lessons - learning cycles and instructional models - has gained popularity in the science education community.

This chapter summarizes recent works on the sequencing of science instruction, including laboratory experiences, in order to facilitate student learning. Specifically, this chapter provides a rationale and empirical support for the 5E Learning Cycle Model.

2.1 ORIGIN OF CONTEMPORARY INSTRUCTIONAL MODELS

Although the idea of instructional models is not new, their application and use has increased dramatically in recent years. A brief history of several instructional models, in particular those that influenced the development of the contemporary BSCS 5E Instructional Model, often referred as 5E Learning Cycle Model are mentioned below.
Herbart’s Model

Johann Friedrich Herbart, a German philosopher, influenced American educational thought around the turn of the 20th century. Herbart considers ‘concepts’ to be the fundamental building blocks of the mind, and the function of a ‘concept’ is the justification for including a concept in a course of study. In a contemporary sense, Herbart was interested in the creation and development of conceptual structures that would contribute to an individual’s development of character.

Herbart proposed two ideas as foundations for teaching, interest and conceptual understanding. The first principle of effective instruction consists of the students’ interest in the subject. Herbart suggested two types of interest, one based on direct experiences with the natural world and the second based on social interactions. Science instruction can quite easily use the natural world and capitalize on the curiosity of students. In addition, teachers can introduce objects from the natural world and use them to help students accumulate a rich set of sense impressions. Herbart suggested the observation and collection of living organisms and the introduction of tools and machines in a science classroom (Herbart, 1901). Herbart’s model also incorporates the social interests of children and their interactions with other
individuals, so that the instructional model should incorporate opportunities for social interaction among students and between students and the teacher.

The second principle of Herbart’s model is the formation of concepts. For Herbart, sense perceptions of objects, organisms, and events are essential, but in and of themselves they are not sufficient for the development of mind. A very important theme in Herbart’s model is the coherence of ideas. That is, each new idea must be related to extant ideas and prior knowledge is the point of departure of instruction.

In summarizing Herbart’s ideas into an instructional model, it begins with the current knowledge and experiences of the students and the new ideas related to concepts, the students already have. Introducing new ideas that connect with extant ideas would slowly form concepts. According to Herbart (1901), the best pedagogy allows students to discover the relationships among experiences. Teachers would guide, question, and suggest through indirect methods. The next step involves direct instruction, where the teacher systematically explains ideas that the student could not be expected to discover independently. In the final step, teachers ask students to demonstrate their understanding by applying the concepts to new situations. Herbart’s model is one of the first systematic approaches to teaching and has been used in various forms by educators for more than 100 years. Fig 2.2 shows the steps of Herbart’s Model and Table 2.1 summarizes Herbart’s instructional model.
Table 2.1

*Herbart’s Instructional Model*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>The teacher brings prior experiences to the student’s awareness.</td>
</tr>
<tr>
<td>Presentation</td>
<td>The teacher introduces new experiences and makes connections to prior experiences.</td>
</tr>
<tr>
<td>Generalization</td>
<td>The teacher explains ideas and develops concepts for the students.</td>
</tr>
<tr>
<td>Application</td>
<td>The teacher provides experiences where the students demonstrate their understanding by applying concepts in new contexts.</td>
</tr>
</tbody>
</table>
Dewey’s Instructional Model

John Dewey began his career as a science teacher and the early influence of science explains the obvious connection between Dewey’s conception of thinking and scientific inquiry. In How We Think (1910, 1933), Dewey outlines what he terms a complete act of thought and describes them as the traits of complete act of thought for reflective thinking and are given below.

![Diagram of Dewey's traits of complete act of thought]

*Figure 2.3 Dewey’s traits of complete act of thought*

In Democracy and Education (1916), Dewey further describes the relationship between experience and thinking. He summarizes the general features of the reflective experience:

- Perplexity, confusion, doubt - due to the fact that one is implicated in an incomplete situation whose full character is not yet determined;
- A conjectural anticipation - a tentative interpretation of the given elements, attributing to them a tendency to affect certain consequences;
A careful survey (examination, inspection, exploration, analysis) of all attainable consideration which will define and clarify the problem in hand;

A consequent elaboration of the tentative hypothesis to make it more precise and more consistent;

Taking one stand upon the project hypothesis as a plan of action which is to the existing state of affairs: doing something overtly to bring about the anticipated result, thereby testing the hypothesis.

The 1938 report on Science in General Education (Commission on Secondary School Curriculum, 1937) expresses Dewey’s model of reflective thinking, and a section on “How the Science Teacher May Encourage Reflective Thinking” describes elements of an instructional model. Table 2.2 synthesizes an instructional model from Dewey’s statements from Science in General Education.

Table 2.2

Dewey's Instructional Model

<table>
<thead>
<tr>
<th>Phase</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing Perplexing Situations</td>
<td>The teacher presents an experience where the students feel thwarted and sense a problem</td>
</tr>
<tr>
<td>Clarifying the problem</td>
<td>The teacher helps the students to identify and formulate the problem.</td>
</tr>
<tr>
<td>Formulating a Tentative Hypothesis</td>
<td>The teacher provides opportunities for students to form hypotheses and tries to establish a relationship between the perplexing situation and previous experiences.</td>
</tr>
<tr>
<td>Testing the Hypothesis</td>
<td>The teacher allows students to try various types of experiments, including imagery, pencil-and-paper, and concrete experiments, to test the hypothesis. The teacher suggests tests that result in acceptance or rejection of the hypothesis.</td>
</tr>
<tr>
<td>Revising Rigorous Tests</td>
<td>The teacher asks the students to device a statement that communicates their conclusions and expresses possible action.</td>
</tr>
</tbody>
</table>
Heiss, Obourn and Hoffman Learning Cycle

By 1950, a variation of John Dewey’s instructional model emerged in science methods textbooks (Heiss, Obourn & Hoffman, 1950). The authors based their “learning cycle” (their term) on Dewey’s complete act of thought. Table 2.3 presents that learning cycle.

Table 2.3

Heiss, Obourn and Hoffman Learning Cycle

<table>
<thead>
<tr>
<th>Phase</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploring the Unit</td>
<td>Students observe demonstrations to raise questions, propose a hypothesis to answer questions, and plan for testing.</td>
</tr>
<tr>
<td>Experience</td>
<td>Students test the hypothesis, collect and interpret data, and form a conclusion.</td>
</tr>
<tr>
<td>Getting</td>
<td></td>
</tr>
<tr>
<td>Organization of Learning</td>
<td>Students prepare outlines, results, and summaries, they take tests.</td>
</tr>
<tr>
<td>Application of learning</td>
<td>Students apply information, concepts, and skills to new situation.</td>
</tr>
</tbody>
</table>

SCIS Learning Cycle Model

In the late 1950s and early 1960s, an era of curriculum reform, Learning Cycle Models were popularized by leaders of the reform movement. In a popular and now-classic article, “Messing About in Science,” Hawkins (1965) describes a teaching model that uses the symbols of the circle, the triangle, and the square. In general, the symbols represent phases of an instructional model that includes unstructured exploration, multiple programmed experiences, and didactic instruction.
The model described by Hawkins provides the basic strategies for the units developed by the Elementary Science Study (ESS). The systematic approach to instruction did not, however, gain the widespread acceptance of other curriculum development studies, in particular the Science Curriculum Improvement Study (SCIS).

Robert Karplus, a theoretical physicist at the University of California–Berkeley, became interested in science education in the late 1950s. His interest led to an exploration of children’s thinking and their explanations of natural phenomena. By 1961, Karplus began connecting the developmental psychology of Jean Piaget to the design of instructional materials and science teaching.

In 1961, J. Myron Atkin, at the University of Illinois, shared Karplus’s ideas about teaching science to young children. Eventually, they collaborated on a model of guided discovery on instructional materials (Atkin & Karplus, 1962). Karplus continued refining his works and tested different instructional materials and observed the responses of elementary children.

By 1967, Robert Karplus and his colleague Herbert Thier adopted the terms that are used today and provided greater clarity and a curricular context as they described the three phases of their model for science teaching. “The plan of a unit may be seen, therefore, to consist of this sequence: preliminary exploration, invention, and discovery” (Karplus & Thier, 1967, p. 40). Fig 2.4 shows the phase of SCIS Learning Cycle.

Figure 2.4 Phases of SCIS Learning Cycle Model
The three phases and the sequence of SCIS Learning Cycle are exploration, invention, and discovery. Exploration refers to relatively unstructured experiences in which students gather new information. Invention refers to a formal statement, often the definition and terms for a new concept. Following the exploration, the invention phase allows interpretation of newly acquired information through the restructuring of prior concepts. The discovery phase involves application of the new concept to another novel situation. During this phase, the learner continues to develop a new level of cognitive organization and attempts to transfer what he or she has learned to new situations.

Table 2.4

*Summary of SCIS Learning Cycle*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>Students have an initial experience with phenomena.</td>
</tr>
<tr>
<td>Invention</td>
<td>Students are introduced to new terms associated with concepts that are the object of study.</td>
</tr>
<tr>
<td>Discovery</td>
<td>Students apply concepts and use terms in related but new situations.</td>
</tr>
</tbody>
</table>

In the mid-1980s, BSCS received a grant from IBM to conduct a design study that would produce specifications for a new science and health curriculum for elementary schools. Among the innovations that resulted from this design was the 5E Learning Cycle Model.
2.2 5E LEARNING CYCLE MODEL

According to Beisenherz and Dantonio (1996), the learning cycle enables students themselves to construct discrete science concepts. It includes an Exploration Phase in which students are exposed to hands-on activities; an Introduction phase in which the concept formally introduced; and an application phase, in which the concept is reinforced and expanded through additional experiences. All phases of the learning cycle use teacher questions to guide the learning experiences.

Initially the learning cycle was not 5E, with the emphasis on constructivism and assessing prior knowledge the Engagement stage has been added, making the learning cycle a 5E model.

![5E Learning Cycle Model](image)

*Figure 2.5 Phases of 5E Learning Cycle Model*

The Table 2.5 given below gives a brief summary of the 5 stages of the learning cycle model.
Table 2.5

Description of the stages of the 5E Learning Cycle Model

<table>
<thead>
<tr>
<th>Stages</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement</td>
<td>Object, event or question used to engage students. Connections facilitated</td>
</tr>
<tr>
<td>Exploration</td>
<td>Objects and phenomena are explored. Hands-on activities, with guidance.</td>
</tr>
<tr>
<td>Explanation</td>
<td>Students explain their understanding of concepts and processes. New concepts</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Activities allow students to apply concepts in contexts, and build on or extend understanding and skill.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Students assess their knowledge, skills and abilities. Activities permit evaluation of student development and lesson effectiveness.</td>
</tr>
</tbody>
</table>

1. **Engagement**

The first phase engages students in the learning task. The students mentally focus on an object, problem, situation or event. The activities of this phase make connections to past experiences and expose students’ misconceptions; they should serve to mitigate cognitive disequilibrium.

Asking a question, defining a problem, showing a discrepant event, and acting out a problematic situation are all ways to engage the students and focus them on the instructional task. The role of the teacher is to present the situation and identify the instructional task. The teacher also sets the rules and procedures for establishing the task.

Engagement is the time when the teacher is on the center stage. The teacher poses the problem, pre-assesses the students, helps students to make connections, and informs students about where they are heading.
The purpose of engagement is to:

- Focus students’ attention on the topic.
- Pre-assess what students’ prior knowledge.
- Inform the students about the learning objectives
- Remind students of what they already know that they will need to apply to learning the topic at hand.
- Pose a problem for the students to expose in the next phase of the learning cycle.

Successful engagement results in students being puzzled by, and actively motivated in the learning activity. Here, the word “activity” refers to both mental and physical activity and they include,

- Observe surroundings for points of curiosity
- Ask questions about the real world
- Consider possible responses to questions
- Note unexpected phenomena
- Identify situations where students perceptions vary

2. Exploration

Once the activities have engaged the students, they have a psychological need to explore the ideas. Exploration activities are designed so that the students in the class have common, concrete experiences upon which they continue formulating concepts, processes, and skills. Engagement brings about disequilibrium; exploration initiates the process of equilibration. This phase should be concrete and hands on. Educational software can be used in the phase, but it should be carefully designed to assist the initial process of formulating adequate and scientifically accurate concepts.

Now the students are at the center of action as they collect data to solve the problem. The teacher makes sure that the students collect and organize their data in order to solve problem. The students need to be active.
The purpose of exploration is to have students collect data that they can use to solve problem that was posed.

The aim of exploration activities is to establish experiences that teachers and students can use later to formally introduce and discuss concepts, processes, or skills. During the activity, the students have time, in which they can explore objects, events, or situations. As a result of their mental and physical involvement in the activity, the students establish relationships, observe patterns, identify variables, and question events.

The teacher’s role in the exploration phase is that of facilitator or coach. The teacher initiates the activity and gives the students’ time and opportunity to investigate objects, materials, and situations based on each student’s own ideas of the phenomena. If called upon, the teacher may coach or guide students as they begin reconstructing their explanations. Use of tangible materials and concrete experiences is essential.

The strategies for this phase can be listed as

- Engage in focused play
- Brainstorm possible alternatives
- Experiment with materials
- Observe a specific phenomena
- Design a model
- Collect and organize data
- Employ problem solving strategies
- Select appropriate resources
- Discuss solutions with others
- Design and conduct experiments
- Evaluates choices
- Engage in debates
- Identify risks and consequences
- Define parameters of an investigation
3. Explanation

The word “explanation” means the act or process in which concepts, processes, or skills become plain, comprehensible, and clear. The process of explanation provides the students and the teacher with a common use of terms relative to the learning task. In this phase, the teacher directs students’ attention to specific aspects of the engagement and exploration experiences. Firstly, the teacher asks the students to give their explanations. Secondly, the teacher introduces scientific or technological explanations in a direct, explicit, and formal manner. Explanations are ways of ordering the exploratory experiences. The teacher should base the initial part of this phase on the students’ explanations and clearly connect the explanations to experiences in the engagement and exploration phases of the instructional model. The key to this phase is to present concepts, processes, or skills briefly, simply, clearly, and directly and to move on to the next phase.

Teachers have a variety of techniques and strategies at their disposal to elicit and develop student explanations. Educators commonly use verbal explanations; but, there are numerous other strategies, such as videos, films, and educational courseware. The strategies commonly used in this phase can be listed below as

- Communicate information and ideas
- Construct and explain a model
- Construct a new explanation
- Review and critique solutions
- Utilize peer evaluation
- Assemble multiple answers/solutions
- Determine appropriate closure
- Integrate a solution with existing knowledge and experiences
- Analyze data

This phase continues the process of mental ordering and provides terms for explanations. In the end, students should be able to explain exploratory experiences and experiences that have engaged them by using
common terms, since students will not immediately express and apply the explanations in scientific terms.

4. Elaboration

Once the students have an explanation of terms for their learning tasks, it is important to involve the students in further experiences that extend, or elaborate, the concepts, processes, or skills. This phase facilitates the transfer of concepts to closely related but new situations. In some cases, students may still have misconceptions, or they may only understand a concept in terms of the exploratory experience. Elaboration activities provide further time and experiences that contribute to learning of the same concept.

Champagne (1987) provides a clear description of this phase. During the elaboration phase, students engage in discussions and information seeking activities. The group’s goal is to identify and execute a small number of promising approaches to the task. During the group discussion, students present and defend their approaches to the instructional task. This discussion results in better definition of the task as well as the identification and gathering of information that is necessary for successful completion of the task. The teaching cycle is not closed to information from outside. Students get information from each other, the teacher, printed materials, experts, electronic databases and experiments that they conduct. These are called the information bases for learning. As a result of participation in the group’s discussion, individual students are able to elaborate upon the conception of the tasks, information bases and possible strategies for the task completion.

Group discussions and cooperative learning situations provide opportunities for students to express their understanding of the subject and receive feedback from others who are very close to their own level of understanding and it constitutes social learning. The major strategies used in the elaborate phase can be given as

- Make decisions
- Apply knowledge and skills to other disciplines
• Transfer knowledge and skills
• Share information and ideas orally and in writing
• Ask new questions
• Develop products and promote ideas
• Use models and ideas to illicit discussions and acceptance by others
• Conduct more investigations
• Conduct activities in other disciplines

This phase is also an opportunity to involve students in new situations and problems that require the transfer of identical or similar explanations.

5. Evaluation

This is the important opportunity for students to use the skills they have acquired and evaluate their understanding. In addition, the students should receive feedback on the adequacy of their explanations. Informal evaluation can occur at the beginning and throughout the 5E sequence. The teacher can complete a formal evaluation after the elaboration phase. As a practical educational matter, teachers must assess educational outcomes. This is the phase in which teachers administer assessments to determine each student’s level of understanding and the major strategies using for the assessment are given below.

• Journals, Logs, etc.
• Portfolios
• Construct mental and physical models
• Student data sheets
• Performance assessments
• Produce a product
• Rubrics and scoring tools
• Tests
Table 2.6

**Summary of the 5E Learning Cycle Model**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement</td>
<td>The teacher or a curriculum task accesses the learner’s prior knowledge and help them to become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experience, expose prior conceptions and organize students thinking towards the learning outcomes of current activities.</td>
</tr>
<tr>
<td>Exploration</td>
<td>Exploration experiences provide students with a common base of activities within which current concepts (i.e. misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them to use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.</td>
</tr>
<tr>
<td>Explanation</td>
<td>The explanation phase focuses student’s attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher may guide them toward a deeper understanding, which is a critical part of this phase.</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Teachers challenge and extend students conceptual understanding and skills. Through new experience, the students develop deeper and border understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>The evaluation phase encourages students to assess their understanding and abilities and provide opportunities for teachers to evaluate student progress towards achieving the educational objectives.</td>
</tr>
</tbody>
</table>
2.3 THEORIES BEHIND THE LEARNING CYCLE

A learning cycle can be considered as an inquiry based, constructivist conceptual change model. The theories behind the learning cycle can be given under the heads as

- Inquiry and Learning Cycle
- Constructivism and Learning Cycle
- Conceptual change and Learning Cycle

Inquiry and Learning Cycle

Inquiry is a critical component of a science program at all grade levels and in every domain of science, and designers of curricula and programs must be sure that the approach to content, as well as the teaching and assessment strategies, reflect the acquisition of scientific understanding through inquiry. Students then will learn science in a way that reflects how science actually works.

According to the National Science Education Standards (NSES, 1996), inquiry is 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.

Much of the research related to inquiry science has been focused on student outcomes and behaviors, and the roles and feelings of teachers as they have encountered this “radical” method of instruction (Berg, Bergendahl, & Lundberg, 2003). A few ways in which students benefit from “science as inquiry” is through increased scientific achievement and more positive attitudes toward science teaching and science as a general topic of interest (Berg et al., 2003; Chang & Mao, 1998; Von-Secker, 2002).

As an instructional model, the learning cycle provides the active learning experiences recommended by the National Science Education
standards. Curriculum designed around levels of inquiry provides a rich context for the implementation of the 5E model of instructional practices. Inquiry provides the overarching framework for curriculum design. The 5E Learning Cycle gives specific guidelines for what teachers should be doing to implement inquiry-based lessons. Together, the curriculum and the specific practices support the teaching and learning of science concepts, as well as the methods and processes of scientific inquiry.

**Constructivism and Learning Cycle**

Constructivism sets the foundation for many instructional methods in Mathematics and Science. As summarized by Wheatley (1991) there are two main pillars of constructivism: (1) knowledge is not passively received but is actively built by students, which can differ from person to person and (2) there is no one correct view of the world, only what is perceived as real by each person as he constructs his meaning of the world through his own experiences.

Although constructivism did not reach mainstream status until the 1980’s, Dewey (1910) has advanced these ideas near the early part of the century. Regarding the personal connection to knowledge he stated - knowledge of human affairs couched in personal terms seems more important and more intimately appealing than knowledge of physical things conveyed in impersonal terms. Only by taking a hand in the making of knowledge, by transferring guess and opinion into belief authorized by inquiry, does one ever get knowledge of the method of knowing.

The realization of the learner as a “constructer” of knowledge and not an empty container to be filled with facts is what differentiates constructivism from other educational theories. Pre-Sputnik era approaches to teaching and learning science possessed behaviorist flair, but afterwards, in the rush to have a nation of better prepared scientists, the focus was on a more student-centered approach for teaching science. This developed alongside Piaget’s ideas of intellectual development (Duit & Treagust, 1998). As children proceed through the sensory-motor, pre-operational, concrete, and formal operational
stages, Piaget suggested that mental processes are engaged in which old and new experiences merge to form new ideas (Karplus, 2003/1977).

The implications of Vygotsky’s (1978) Zone of Proximal Development in education include that it exemplifies “the development process lags behind the learning process” (p. 90) and “shows that the initial mastery provides the basis for the subsequent development of a variety of highly complex internal processes in children’s thinking” (p. 90). Driver, Leach, Scott, & Wood-Robinson (1994) add that Vygotsky viewed science knowledge as constructed through relationships that also had a cultural and social connection.

A key component of constructivist thinking is that students have numerous personal experiences before they are formally educated, which shape how they perceive the world around them. This approach to constructivism can be observed through the science classroom model of conceptual change.

**Conceptual Change and Learning Cycle**

Conceptual change is still considered as a relatively new area of research in science (Duit & Treagust, 1998). The idea of conceptual change spawned from studies in the 1970s of students’ misconceptions in science and how misconceptions can be changed (Posner, Strike, Hewson & Gertzog, 1982).

Thomas Kuhn (1977) referred to the experience one has when encountering new phenomena or finding dissatisfaction with current ideas as a scientific revolution. To better elucidate such a change he uses the analogy of a scientist as “solver of puzzles”.

According to Kuhn’s analogy, imagine the scientist, or student, holding a puzzle piece (a current conception) and no matter how it is turned, it will not fit into the larger whole and so he begins searching for another piece. In the words of Posner et al. (1982), this is categorized as an anomaly. This is what must occur first for conceptual change to be successful; if discontent with the current idea is not achieved then there is no basis for change. When an
anomaly occurs, the learner’s behavior is typically associated with one of the following courses of action.

(1) Rejection of the observational theory.

(2) A lack of concern with experimental findings on the grounds that they are irrelevant to one’s current conceptions.

(3) A compartmentalization of knowledge to prevent the new information from conflicting with existing belief.

(4) An attempt to assimilate the new information into existing conceptions.

According to Posner et al. (1982) simply supplying information and facts falls far short of the true basis of intelligibility. For a new concept to be integrated into the student’s current thinking, he or she must exhibit a clear understanding that can be communicated to others. It is up to the student if this stage of conceptual change is attained, as the plausibility of a concept must fit harmoniously with a student’s beliefs and prior experiences, even those that may be unrelated to science. The fruitfulness of a new concept is attained when it meets the previously stated criteria and the learner can begin extending this understanding to other concepts and create new ideas.

2.4 5E AS AN INQUIRY BASED, CONSTRUCTIVIST, CONCEPTUAL CHANGE MODEL

One way to address constructivism, conceptual change, and inquiry learning in a classroom setting is through the 5E Learning Cycle Model. According to Bybee (1997) 5E Learning Cycle Model influenced greatly by the works of German philosopher Johann Friedrich Herbart, John Dewey and Jean Piaget.

Given the input of Herbart, Dewey, Piaget and such influential contributors to educational research, it should be no surprise that the 5E model is rooted in constructivism and is supported by research that addresses the methods for conceptual change (Bybee & Landes 1990). According to Bybee and Landes (1990), “the objective in a constructivist program is often to
conceptual framework

challenge students’ current conceptions by providing data that conflict with students’ current thinking or experiences that provide an alternate way of thinking about objects and phenomena” (p. 96).

Expanded from Karplus and Atkin’s (1967) learning cycle stages of exploration, invention, and discovery, the 5E model meet these conditions for conceptual change by having students “redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment…and interpret objects and phenomena” (Bybee, 1997, p. 176).

Indications of constructivism in the 5E model are evidenced in the first phase, Engagement. Here, students’ prior knowledge of a concept is elicited and connections to present and future topics are encouraged. Typically a discrepant event, questioning, or some other act secures the learners’ attention and interest in the topic (Bybee, 1997). The instructor’s role in this phase is that of a key as the instructor is expected to “raise questions and problems, create interest, generate curiosity and elicit responses that uncover students’ current knowledge” (Bybee, 1997, p. 178). Quite possibly, this is the most critical phase of the model; if the material is not presented well, students may not make the necessary associations to fully interact with the topic and the remaining phases become meaningless.

During Exploration, it is meant for all students to “have common, concrete experiences upon which they continue building concepts, processes, and skills” (Bybee, 1997, p. 177). With all students sharing the same activities, a point of reference is formed for later discussions and connections to past and future investigations. The teacher’s role during exploration is that of a facilitator as she encourages cooperative group discussions by asking guiding questions and serves as a resource for students. In a study conducted by Lindgren and Bleicher (2005) pre-service teachers who were learning the learning cycle found this stage to be central to the process as they were able to “explore, discover, investigate, and act like a scientist” (p. 69) during this phase. Cooperative learning is also employed in this phase, which likely leads to rich discussions among students and perhaps a state of disequilibrium as
they might begin to combat misconceptions and experience a conceptual change through their inquiry (Bybee, 1997).

The crux of the Explanation phase is “to present concepts, processes, or skills briefly, simply, clearly, and directly” (Bybee, 1997, p. 180) and so one can see how the role of the teacher is so pivotal during this phase. As she assists students in understanding the connections between their own interpretations and formal science phenomena, many instructional strategies such as videos, software, and literature are utilized. At the beginning students are asked to provide their explanations from events during the explore phase and then the formal science language is introduced (Bybee, 1997). In addition to simply providing their own thoughts, students are also expected to listen to and question others’ explanation, which in turn enhances their own learning.

As the meaning of the word states, in the Elaboration phase students are encouraged to extend their understanding of a scientific concept of past, what they have experienced through the previous three stages. In Bybee’s (1997) words “generalization of concepts, processes, and skills is the primary goal of the elaboration phase” (p. 181). To achieve this goal the teacher encourages students to use formal science terms as they complete related activities and identify alternative ways to explain phenomena. Those who still hold misconceptions or have not yet achieved dissatisfaction with their current ideas may be able to clarify their perceptions through this extension of learning (Bybee, 1997).

As with all effective instructional methods, there must be a stage in which students’ understanding of concepts must be gauged and in the 5E model that is the Evaluation phase. Although some type of informal evaluation has been occurring throughout the inquiry, in this phase it is specific to formal assessment (Bybee, 1997). This assessment is not in the form of a multiple-choice test. On the contrary, evaluation in the 5E model includes open-ended questions or demonstrations and often probing questions that will lead to the next inquiry. Also unique to other types of assessment is the student’s opportunity to evaluate his own understanding and growth in relation to the
concept in the 5E model (Bybee, 1997). The crux of 5E Learning Cycle Model is given in Fig 2.5

![5E Learning Cycle Model](image)

Figure 2.6 5E Learning Cycle Model

Apart from its completeness and foundations in research, a learning model cannot “make” students learn on their own. “A learning model does not prescribe a unique set of teaching sequences and strategies; and a particular teaching strategy does not determine the type of learning that will occur” (Hewson, Beeth & Thorley, 1998, p. 199). Bianchini and Colburn (2000) found the role of the classroom teacher to be pivotal in leading discussions, answering questions, and modeling the ideas supporting the natures of
science, which in turn guided the students toward a more conceptual understanding of science.

Although the 5E model is conducive in providing the experiences necessary for conceptual change, it is only through the questioning techniques and awareness of the instructor that this model proves effective (Bybee, 1997; Bybee & Landes, 1990). Neither can these changes be undergone in isolation; students need the opportunity to confer, argue, and share with others to confirm their own thoughts and explanations, which is why cooperative learning is imperative for success in Science.

**Figure 2.7 5E Learning Cycle both as Constructivist and Conceptual change Model**

In this strategy it is obvious that students must be actively engaged to display the features of scientific thinking. The teacher works on the misconceptions or the previous knowledge of the learner and then accommodates the new concept into the cognitive structure of the learner and give opportunities to brood on the concepts and the construction of new knowledge than adopting the knowledge claims of others.
2.5 CONCLUSION

The present chapter Conceptual Framework enabled the investigator to understand that, the 5E Learning Cycle Model is grounded on sound educational theories. It has a growing base of research to support its effectiveness, and have a significant impact on science education. The conceptual framework of the study threw light in to the nature of the instructional model and knowledge of each phase of the 5E Learning Cycle helped the investigator to frame the lesson transcripts for the study. The strategies that can be used in each phase of the learning cycle helped the investigator to select the appropriate strategy to each phase in the preparation of lesson transcripts. Evaluation of each phase of learning cycle directed the investigator in to the correct path of conceptual attainment.