Helical Learning Model

Jerry O'Connor, Eric Peterson, J. A. G. Gomes, David L. Cocke
San Antonio College, Lamar University, USA

Abstract

A popular model employed to represent the learning process is typically portrayed as a four-stage process signified by a cycle in a two-dimensional circular path. This cycle can be repeated by revisiting topics at increasing levels of sophistication in order to produce what is known as a spiral curriculum. In this presentation, a variation of Kolb's two-dimensional learning cycle model is offered that represents the learning cycle as if it were a three-dimensional spiral, or helix, with successive turns associated with Bloom's Taxonomy levels. This representation is explored and developed to provide an alternative means to visualize the learning process in the hope that the new perspective may lead to a more comprehensive model for the learning cycle and to a broader implementation of more effective curricula and teaching practices.

Introduction

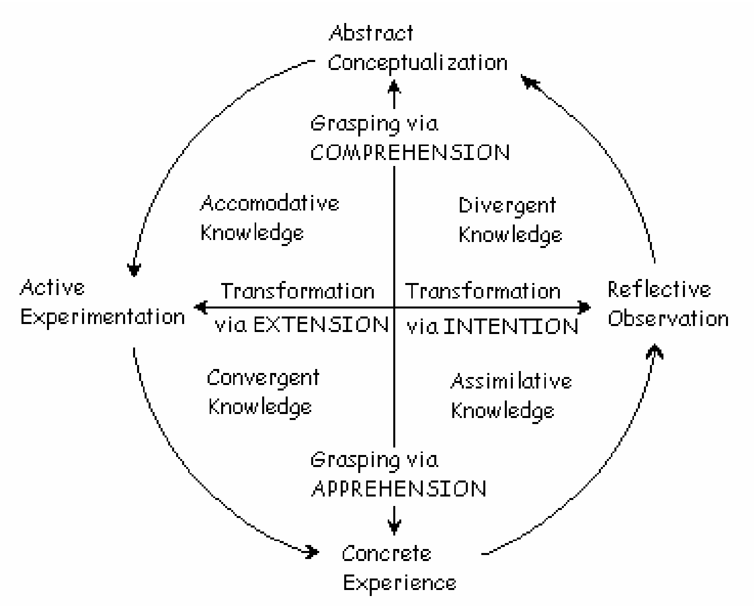
Physics Education Research (PER) in the United States has made a substantial contribution to our understanding of common difficulties students encounter when trying to learn physics and has also produced strategies to address some of these difficulties [1,2,3]. Redish appears to be one of the first to attempt to synthesize a comprehensive model as a framework in which to interpret and apply PER findings [3,4,5]. In the application of these findings, he acknowledges the importance of individual learning styles and using a variety of approaches to effectively "match the impedance" of different styles. This paper presents a model that unifies four fundamental learning styles and a corresponding learning cycle with a set of cognitive objectives for higher level learning outcomes. The purpose of the model is to provide an alternative representation of the learning process and a framework in which to more effectively apply both conventional and research-based strategies in the classroom.

Learning Styles

A systematic study of learning styles was carried out by Kolb [6], and his cyclic learning model has been widely applied in the Engineering Education community for more than a decade [7, 8]. Based on the work of John Dewey, Kurt Lewin, and Jean Piaget, its central idea is that "learning is the process whereby knowledge is created through the transformation of experience", or more descriptively, "Learning, and therefore knowing, requires *both* a grasp or figurative representation of experience and some transformation of that representation" [6, p.38, 42]. This does not sound very different from Arons, "to help the learner assimilate abstract concepts, it is essential to engage the learner's mind in active use of the concepts in concrete situations. The concepts must be explicitly connected with immediate, visible, or kinesthetic experience" [1, p.38]. In Kolb's structural model, there are two complementary modes of grasping experience on one axis, and two complementary modes for transforming the experience on a second axis, orthogonal to the first (figure 1). The experience may be concrete and external (perceptions) or abstract and internal (conceptions), and the transformation may be by intention (reflective and internal) or by extension (active and external).

These two opposing dialectic polarities give rise to four possible combinations of experience and transformation, and a complete cycle composed of all four combinations is supposed to produce the highest level of learning. Kolb created an instrument to assess which modes students use in learning situations and found that most individuals exhibit a preference for one of the four combinations, or learning styles. If you have taught physics laboratory sections, you have probably witnessed (concrete experience) students responding to the apparatus in front of them in two distinct ways. One is characterized by the student sitting back and watching (reflective observation) while another student immediately begins to play with it (active experimentation). Upon witnessing a scene like this, you might have responded to this experience in one of the same two ways: noting that the distinct behaviors represent a recurring pattern (reflective observation), or by initiating some action (active experimentation) that might end the distraction. There are at least two arguments for the adoption of a pedagogic approach that recognizes different learning styles. One is that by addressing all four possible learning styles in a cycle of classroom activities, more students will be able to master the course material. The second is that by having each student practice all four learning modes, they can become more proficient and successful learners. By systematically incorporating the experiential phase of the learning cycle in classroom activities, we may also help achieve the more "thorough interweaving of the physics with explicit connections to the students' experience" called for by Redish [3, pp. 61-62].

Figure 1: Kolb's Fundamental Learning Modes



Learning Cycles

Kolb's learning cycle is not the only one that has been proposed, but it does appear to be the most deeply anchored in cognitive psychology and philosophy. One example of a simplified learning cycle for science has been presented by Lorsbach [9] (figure 2). A noteworthy aspect of the latter model is that it includes an explicit recognition of the need to identify pre-existing knowledge which may not be compatible with the concepts we are trying to teach. The identification of existing physical "knowledge" is also explicitly recognized in the three-stage cycle of "elicit/confront/resolve" utilized by the PER Group at the University of Washington [10]. Although this element does not appear explicitly, it can be clearly recognized in Kolb's introduction to the model, which anticipates some salient PER findings: "In many cases, resistance to new ideas stems from their conflict with old beliefs that are inconsistent with them. If the education process begins by bringing out the learner's beliefs and theories, examining and testing them, and then integrating the new, more refined ideas into the person's belief systems, the learning process will be facilitated" [6, p.28].

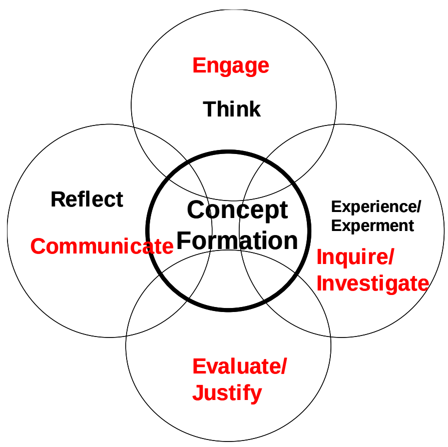
He goes on to describe two mechanisms for the adoption of new ideas that were previously identified by Piaget as integration and substitution. Kolb further states, "Ideas that evolve through integration tend to become highly stable parts of the person's conception of the world. On the other hand, when the content of a concept changes by means of substitution, there is always the possibility of a reversion to the earlier level of conceptualization and understanding, or to a dual theory of the world where espoused theories learned through substitution are incongruent with theories-in-use that are more integrated with the person's total conceptual and attitudinal view of the world" [6, p.28-29]. How these "theories-in-use" can function to inhibit effective physics learning has been addressed in more detail by Redish [3, Chs. 2-3]. A concise summary of learning cycle models for pre-college science teaching has been presented by Sunai [11].

Figure 2: Lorsbach's Learning Cycle

Learning Cycle Variations

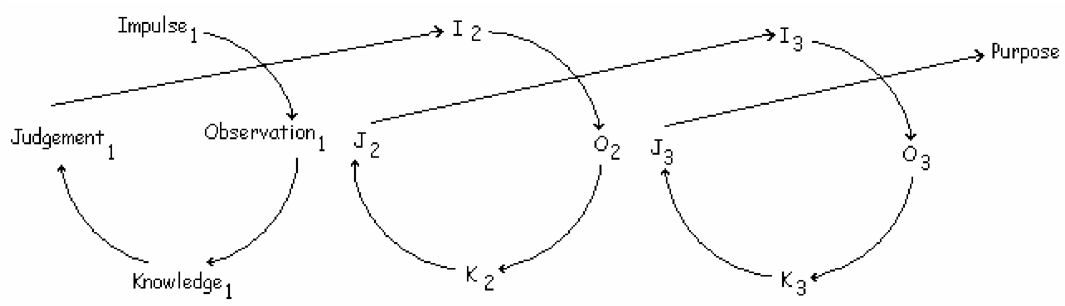
In a more recent study, it was noted by my co-authors that one of the challenges associated with the effective application of evolving digital pedagogies was to effectively harness the power of conceptualization and modeling in the learning process [12]. After exploring Kolb's cyclic learning model and reviewing their experience with the results of problem-based-learning, they concluded that "conceptualization" should be re-positioned from a single stage to a central element in the learning cycle (figure 3).

Figure 3: A Modified Kolb Learning Cycle



A critical limitation of any two-dimensional cyclic learning model is that the final stage of the cycle appears to return the system to its initial state. If a learning "cycle" has been successful, the process must bring the learner to a new state in their concept-space. That the learning cycle is more of a spiral than a circle was perhaps first formally recognized by John Dewey, and this is represented in a depiction of Dewey's model of experiential learning in figure 4, adapted from [6, p.23]. A "spiral" approach to the attainment of educational objectives was proposed by Bruner more than forty years ago [13]. Student difficulties with the assimilation of fundamental scientific concepts have been addressed extensively by Arons [1]; he recognized that the learning process was very slow for most students, and required repeated encounters with the concepts in increasingly sophisticated contexts. In consonance with Bruner, he strongly advocated spiraling back (through the course material and/or the curriculum) for these reviews. A spiral approach to producing new curricula adopted by Lillian McDermott and the PER Group at the University of Washington was acknowledged by Redish as cycling "in a helix of continuous improvement" [14], and a helical format was employed by Collura, et.al. to represent a Multidisciplinary Engineering Foundation Spiral [15].

Figure 4: Dewey's Model of Experiential Learning



Cycle or Spiral?

Although the helix has been used as a model for curriculum structure and development, it does not appear to have been applied as an alternative model for representing the learning cycle. In this application however, the helix can provide a direct correspondence between successive turns and the levels of Bloom's hierarchy of educational objectives. The Bloom Taxonomy (table 1) was developed to provide a hierarchical structure or ranking of cognitive abilities [16].

Table 1: Bloom's Taxonomy of Cognitive Objectives

Bloom level	category	description
1	knowledge	recall of information/ideas
2	comprehension	meaning of information/ideas
3	application	use of information/ideas
4	analysis	resolution of information/ideas
5	synthesis	recombination of information/ideas
6	evaluation	judge value of information/ideas

In a geometrical representation of this model, the Kolb learning cycle in the x-y plane is combined with the Bloom model in the z direction, and the concept to be developed is aligned with the axis of the helix, thus assuming the central role suggested by Cocke. A learner's progression along (or projection on) the axis of the helix (z) could be portrayed in either a discrete or continuous fashion. A continuous trajectory might result from the gradual accumulation of knowledge and be modeled by assigning a z-component to the stages in the Kolb cycle. A discrete learning event may occur at any point in the cycle where there is a resonance between the conceptual configuration of the learner and the confluence of conditions in their environment and be represented by a singularity (*iz*) in a complex Kolb plane. In this picture, the gradual "dawning of enlightenment" and the "Eureka moment" could be considered as alternative representations for a reconfiguration of the learner's self-constructed concept-space. If this reconfiguration were to be brought into correspondence with a real physical process, such as the development of new neural connections, some investment of physical energy would be required. It might then be possible to associate a latent energy with the reconfiguration process, and we could begin to speak of the binding energy of the concept. This viewpoint may provide a mechanism to explain the persistence of the common naïve conceptions that students bring to our classes and how these can inhibit further concept development. The geometry of this model also lends itself to representing of the idea of a "resistance to learning" in terms of an inductive self-impedance.

Harnessing the Helix

In an ideal application, the learning cycle would begin with a concrete experience (discrepant events are particularly effective in securing students' attention and exposing common naïve conceptions). The experience would be followed by activities that foster reflection, description, and interpretation of the meaning of the event. The next phase would be abstract conceptualization, where the event might be represented symbolically or explained in terms of more general ideas (schemas) or theories. The implications and/or practical applications of the ideas would be realized in the next stage of active experimentation. This experimentation leads into another 'cycle' with a concrete experience at a higher cognitive level than the previous event.

Many of the prescriptions provided by Arons [1] are consistent with this model and appear to have been incorporated into the more recent research-based curricula included in The Physics Suite [3]. Some of these curricula have been infused with computer-based laboratory activities and consequently are able to address all four learning modes in a progressive Bloom sequence. These curricula have achieved the largest learning gains. Table 2 presents a variety of conventional and research-based methods along with the associated learning styles addressed. This mapping is provisional and subject to modification. Activities that utilize group interactions can also address learning styles that are oriented toward concrete experience (I and IV), and some activities such as traditional "cookbook" laboratory exercises may address multiple styles, but not in a productive sequence.

Table 2: Learning Styles addressed by Instructional Methods

Instructional Method	Kolb Learning Styles Addressed			
Traditional Lecture		II		
Lecture Demonstrations	I			
Interactive Lecture Demonstrations	I	II	III	
Peer Instruction	I	II	III	
Traditional Recitation		II		
Interactive Recitation		II	III	
Cooperative Problem Solving	I	II	III	
Tutorials in Introductory Physics	I	II	III	
Activity Based Physics Tutorials	I	II	III	IV
Traditional Laboratory	I		III	IV
RealTime Physics	I	II	III	IV
Workshop Physics	I	II	III	IV
Physics By Inquiry	I	II	III	IV
Traditional Homework Problems			III	
Ranking Tasks and TIPER'S (ind.)			III	
Ranking Tasks and TIPER'S (group)	I		III	

Conclusion

A wide variety of conventional and research-based methods are available to help us attain course objectives. Traditional instructional methods do not address the variety of learning styles utilized by our students and have not proven to be as effective as instructional methods developed from the findings of PER. However, some of the more effective methods, which integrate a sequential engagement of all four learning styles along with a progression in cognitive objectives, may be difficult to implement in some situations.

Kolb's structural model of the learning process provides a framework for selecting and sequencing course activities to increase productive learning outcomes for more students in any situation. The calibration of each successive cycle of learning activities with the Bloom cognitive levels can facilitate a more systematic progression of course activities, within a course as well as between courses and grade levels. The combination of these two strategies in a single model may help provide for a more systematic and successful application of the instructional methods at our disposal.

Acknowledgments

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