Adv Physiol Educ 40: 17–25, 2016;
doi:10.1152/advan.00132.2015.

Learning theories 101: application to everyday teaching and scholarship

Denise Kay and Jonathan Kibble

Medical Education, College of Medicine, University of Central Florida, Orlando, Florida

Submitted 4 September 2015; accepted in final form 22 December 2015

Kay D, Kibble J. Learning theories 101: application to everyday teaching and scholarship. *Adv Physiol Educ* 40: 17–25, 2016; doi:10.1152/advan.00132.2015.—Shifts in educational research, in how scholarship in higher education is defined, and in how funding is appropriated suggest that educators within basic science fields can benefit from increased understanding of learning theory and how it applies to classroom practice. This article uses a mock curriculum design scenario as a framework for the introduction of five major learning theories. Foundational constructs and principles from each theory and how they apply to the proposed curriculum designs are described. A summative table that includes basic principles, constructs, and classroom applications as well as the role of the teacher and learner is also provided for each theory.

learning theory; curriculum design; instructional design; behaviorism; social learning theory; social cognitive theory; constructivism; social constructivism; cognitive learning theory

IN WRITING THIS ARTICLE about theories of learning, we are reminded of the tongue-in-cheek opening remarks in an essay by Ernest Bayles in 1966 (9):

> It has long been the plaint of teachers that the theoretical has no value for them because it seems to have no connection with matters they must attend to from day to day. They do not have time for things that are irrelevant. Their time and energy must be given to that which makes a difference.

Like Bayles, our own bias is that successful outcomes in the classroom are more likely when our teaching practice is underpinned by an appreciation of why things work. To address concerns for relevancy, we present a mock case study of a new undergraduate human physiology laboratory class where different course proposals are reviewed through the lens of learning theories. Our intention is to make this narrative accessible to faculty members who are subject matter experts in physiology but who do not have prior training in educational theory as well as to provide a high-yield bibliography for further study.

The traditional pathway to becoming a distinguished educator involves a long apprenticeship of observing and emulating colleagues as well as a process of trial and error (24). Wilkerson and Irby (40) described a career development arc that begins with the acquisition of basic teaching skills, such as presentation and facilitation, giving feedback, and grading. As teaching faculty members gain mastery over basic teaching skills, their focus on performance shifts away from their own implementation to more of a focus on identifying connections between their performance as a teacher and their students' learning outcomes. A subset of these more expert teachers will evolve into teacher-scholars and likely into positions of educational leadership, where a stronger foundation in educational theories is needed to design research studies or to evaluate educational programs.

Changes in educational research have also increased the need for faculty members to be able to understand and apply learning theories and conceptual frameworks to research and practice. At the start of this century, there was a broad acceptance that the definition of scholarship in higher education should be expanded to include the scholarship of teaching (16, 20). At around this time, the outgoing Editor-in-Chief of *Advances in Physiology Education*, Penelope Hansen, rightly reflected on a notable increase in sophistication of educational research in physiology and the greater incorporation of formal research methods (22). While that trend has certainly continued, Bordage has since made a strong case that the design of our educational studies should include a foundation in conceptual frameworks (13). Faculty members aiming to secure external funding for education research are likely to benefit from casting their ideas within theoretical frames of reference. Our hope, in this short review, is to introduce major learning theories as a frame of reference for faculty members to reflect on how to best help learners succeed as well as to inform their own teaching practice and research efforts.

Scenario: Approaches to Designing a New Undergraduate Human Physiology Laboratory Course

The setting is a Southeastern state university with >1,000 prehealth undergraduate students who are producing a high demand for courses in human anatomy and physiology. There is currently only one upper-division course in human physiology. It is a 3-credit hour, one-semester course. The class provides a foundation in premedical human physiology, with an emphasis on knowledge and understanding of physiological mechanisms. It is delivered face to face by traditional lectures. It is assessed by two midterm multiple-choice exams and a cumulative final exam that also includes essay questions. The curriculum committee discusses a preliminary idea to develop a new laboratory class in human physiology that would extend the current class to a 6-credit, two-semester course. The intention is to provide students the opportunity to obtain and interpret data as well as to deepen their understanding of human physiology. The curriculum committee is favorable to the general concept and solicits course proposals.

The following mock proposals represent submissions from different groups of faculty members who adopted different theoretical frameworks in their proposal designs. Basic tenets of their adopted learning theory and the specific components of the proposal that align with that theory are presented.

Curriculum Design Proposals

Curriculum design proposal 1. Learning theory: behaviorism. Before each laboratory session, students will attend a 15- to 30-min lecture about the goal of the laboratory and major

Address for reprint requests and other correspondence: D. Kay, College of Medicine, Univ. of Central Florida, 6850 Lake Nona Boulevard, Orlando, FL 32827 (e-mail: Denise.Kay@ucf.edu).

points of the protocol. Students will be provided with a detailed protocol and data sheet for that laboratory session. For credit, clicker questions are included in each lecture to ensure that students pay attention and can recall key elements of the protocol.

Once in the laboratory, students perform the experiments alone, following the written protocol and completing the question prompts provided on the data sheet. Points are assigned for the completeness and accuracy of data recorded in the data sheet tables. Feedback is provided each week to point out omissions and improve accuracy in making measurements. Additional points can be deducted from the final score if mistakes made in early practicals are repeated in later practicals.

The instructor provides a 15- to 30-min lecture at the end of each laboratory class, discussing key findings and the underlying physiological mechanisms. The final assessment includes a written laboratory report requiring students to express their understanding of the method and rationale for the data. Bonus points are awarded if all laboratory reports are completed on time and all sections are filled out. The exercises are all graded on a scale of A, B, C, D, and F.

COMMENTARY: WHAT IS BEHAVIORISM? Behaviorism was the first learning theory to scientifically explain both animal and human learning. A behaviorist focuses on measurable changes (increase, decrease, or maintenance) in behavior that result from an organism's interactions with the environment. Educators adopting a behaviorist approach are concerned with what students do (responses) as a result of environmental cues (antecedents or stimuli) and environmental consequences. For a true behaviorist, there is no concern for what or how students think or feel (12, 41).

Behavioral research contributed to our understanding of how to shape both animal and human behavior through the use of conditioning strategies, such as positive reinforcement, negative reinforcement, and punishment (41). Behaviorism is teacher centered (12); the teacher's role is to control the environment, design environmental cues or stimuli, and identify the appropriate reward structures to reinforce desired behaviors and decrease undesired behaviors or responses (36). For a staunch behaviorist, the student is seen as an unreflective responder and highly amenable to environmental controls. The student's primary task is to respond appropriately to environmental cues and stimuli; in short, to do what they are supposed to do when they are supposed to do it and subsequently reap the intentional or unintentional rewards (12, 41). Theorists associated with behaviorism include Thorndike, Pavlov, Skinner, and Watson (9, 41).

Despite much controversy over behavioral approaches to teaching, the theory has made significant contributions to pedagogy, including direct teaching, contingency contracts, the role of incentives and reward structures (36), the role of repetition and feedback (9), the importance of clarifying learning objectives, and the introduction of behavior management strategies, such as functional behavior assessment and positive behavioral supports (42). While several new theoretical approaches have been adopted for classroom practice, educational researchers continue to explore how principles of behaviorism are relevant to today's learning environments. For example, educators in postsecondary settings have explored how the use of active student response systems, such as response cards or classroom response systems, and daily and weekly assessments influence students' assessment scores and/or course grades, participation, and perceptions (15, 18, 30).

COMMENTARY: HOW DOES CURRICULUM DESIGN PROPOSAL 1 EXEMPLIFY BEHAVIORISM? In this design, students are provided with clear protocols and the sequential steps needed to complete the experiments. Their task is to understand and successfully deploy the instructions. A key element here is feedback. For example, the clicker questions provide immediate feedback about understanding of the protocol, and feedback on the data sheets indicates how successfully the instructions were followed. Positive reinforcement and punishment are used to progressively shape behavior to achieve the final target behavior of making accurate measurements, correctly reported. The summative points available at several times in the exercise serve as a positive reinforcer, with incentives for higher performance provided using a grading scale of A, B, C, D, and F. The possibility of losing points represents a punishment that serves to decrease mistakes. Having students work alone is a strong behaviorist element since individual demonstrations of behavior are at the center of the learning experience.

Curriculum design proposal 2. Learning theory: social cognitive theory. Students will be provided with detailed protocols for a series of prescribed weekly laboratory classes. Before each laboratory session, a faculty member will demonstrate the protocol, emphasizing the skills needed to obtain accurate measurements (e.g., blood pressure). Students will also receive a course handbook that includes templates for how their final reports for the laboratory sessions should look as well as examples of good and bad reports.

In the laboratory, students work in pairs and give each other feedback on how well the experiment is conducted. Each week, students fill out a self-assessment rating how well they executed the protocols and their degree of confidence in performing the required skills. Graduate student teaching assistants (TAs) observe the performance of each student pair. The TA assigns two scores per student pair each week. One score reflects the student pairs' ability to accurately perform the required protocol; the other score reflects the degree of improvement during the course. The TA debriefs the students to calibrate their levels of perceived confidence with their observed performance.

The instructor provides a 15- to 30-min lecture at the end of each laboratory class, discussing key findings and the underlying physiological mechanisms. Periodic short summative quizzes are administered throughout the semester. Student pairs are asked to hand in a completed report for any 5 of the 15 weekly laboratory classes in the course. Reports are submitted on a flexible basis, so long as all reports are handed in before the end of the course.

COMMENTARY: WHAT IS SOCIAL COGNITIVE THEORY? Social cognitive theory is derived from the extensive work of Albert Bandura. While Bandura acknowledged the role of environmental reinforcement in shaping behavior, he recognized the limitations of behaviorism in fully explaining behavior change (41). His research demonstrated that behavior change could be induced through observational learning, wherein an individual behaves in a given way as a result of a vicarious observation of the positive or negative consequences experienced by someone

else displaying similar behavior. Bandura argued that these observations and experiences were symbolically represented in the mind and subsequently accessed to inform future behavior (8). According to Bandura, learners engage these cognitive representations when they anticipate the consequences of a given response. As such, he was one of the first to consider how cognition mediates behavior (6). His original theory, termed social learning theory, was expanded to incorporate the role of cognition in explaining behavior and is now commonly referred to as social cognitive theory.

Bandura also established the critical role of models, modeling, and observational learning in the learning process. He described modeling as a "psychological matching process" that had broader effects than mere behavior imitation (7).

According to Bandura, observational learning includes four processes:

1. Attention. This process determines what is observed and extracted from modeled events.

2. Retention. This process includes retaining knowledge about the modeled event, which is important as learners can't repeat or be informed by events they can't remember.

3. (Re)Production. This process requires learners to convert memories related to an event into appropriate actions.

4. Motivation. This process relates to the incentive (or lack of) to demonstrate learned behavior. Learners may have accurate memories of the modeled event and be able to successfully translate those to behavior. However, their willingness to do so is frequently associated with the observed benefits or consequences of that behavior when performed by others (7).

Bandura's theory challenged previous theories that attributed behavior change to unidirectional forces wherein either the environment fully impacted the individual or the individual fully impacted the environment. Instead, Bandura proposed that observable behaviors resulted from what he termed "triadic reciprocal causation" or shifting bidirectional interactions among behavior, personal (internal), and environmental factors. From this perspective, "People are both products and producers of their environment" (41).

Bandura was also among the first to explore the relationship of personal factors, such as self-regulation, self-efficacy, and personal agency to learning and performance. Personal agency represents an individual's capacity to make and subsequently act on choices that can make a difference in his/her life (31). Although easily confused, agency differs from self-efficacy. The latter refers to one's belief about personal ability "to organize and execute courses of action required to attain designated types of performances" (7). Collective research has established the critical role of self-efficacy for explaining learning and performance in a variety of settings (34). Similarly, research has established the critical role of self-regulation in relationship to academic achievement (11, 45).

Bandura is one of the most widely cited researchers in psychological and educational literature. His model of observational learning is highly useful when the learning goals are best achieved via instructional modeling, demonstration, and imitation (44). The roles of self-efficacy and self-regulation and the benefits of teaching self-regulation strategies to students have been the focus of extensive research on human learning, performance, and motivation (34). His creation of self-directed learning programs built on proximal learning goals have been associated with enhanced self-efficacy beliefs and achievement in mathematics, reading, and writing (6, 11, 45). Bandura believed that, through activation of forethought (anticipatory thoughts), anticipatory beliefs about the potential for success (efficacy), and self-regulation, people implement and sustain courses of action to achieve desired outcomes (5). As such, optimal instruction uses personal agency, as well as social and environmental variables, to shape appropriate behavior and to build both content knowledge and underdeveloped self-regulatory skills (6).

COMMENTARY: HOW DOES CURRICULUM DESIGN 2 EXEMPLIFY SOCIAL COGNITIVE THEORY? This design includes several elements of modeling and imitation. For example, the instructor spends time demonstrating necessary skills and provides report templates and samples to guide students' performance. The four elements of observational learning are also represented: the attention element is assumed with the lecture and demonstration, the retention element is assured by the regular inclusion of summative quizzes, the reproduction element is triggered with the student pair activity and the submission of the required five reports, and the motivation element comprises the quizzes, required reports, TA observations and score given for improvement over time. Self-regulation is encouraged as students work in pairs to independently complete the laboratory protocols, determine which laboratory reports to complete, and then work together to complete and submit them. Including the confidence ratings in the students' self-assessment of performance allows the TA to regulate gaps between students' performance and their reported level of confidence.

Curriculum design proposal 3. Learning theory: cognitive learning theory. The faculty member designs a series of laboratories for each body system that steadily build in complexity in terms of the underlying physiology. As an example, in the cardiovascular laboratory sequence, the first class demonstrates Ohm's law relating pressure, flow, and resistance using a series of fluid chambers set at different heights connected by tubing of different diameters. Later in the sequence, students are challenged to measure blood pressure and then to apply concepts to postural changes, exercise, etc.

Mastery learning goals are used in this design. Before each body system laboratory set, there is a pretest based on knowledge that should have been retained from the lecture course that students completed the previous semester. Students can take the pretest as many times as needed to demonstrate mastery (get all items correct) of the prior material. After each laboratory, there is a cumulative quiz that includes questions from both current and prior laboratory sessions. Similar to the pretest, students must demonstrate mastery of all items to proceed to the next, more difficult laboratory exercise. The final and most complex laboratory in each sequence is assessed by requiring each student to develop a concept map demonstrating his or her understanding of the underlying physiology. The concept maps are scored by two faculty members and comprise the largest component of the final grade. Points are awarded for the number of concepts, selection of critical concepts, accuracy of links between concepts, and overall complexity of understanding depicted in the map.

COMMENTARY: WHAT IS COGNITIVE LEARNING THEORY? As opposed to behavioral theories that focus on changes in behavior, cognitive theories of learning focus on how knowledge is acquired (35), constructed, and represented in the mind and subsequently remembered. Behavioral and cognitive theories

also differ in their perspectives of the role of the learner. In behaviorism, learners are passive responders to environmental stimuli. In the cognitive perspective, learners are active agents in the learning process. Each learner comes to the learning experience with different levels of prior knowledge, skills, and motivation that influence learning outcomes (42).

One focus of cognitive science has been on how information is mentally processed and stored. A popular information processing framework divides memory into three components: sensory register, short-term memory, and long-term memory. At any given moment, learners are bombarded with stimuli via their senses. The sensory register is the stimulus receiver, sort of the mind's satellite dish. Here, information is coded and held briefly (1–3 s). If this information is not attended to, it is quickly lost. However, if a learner pays attention to the stimulus, that information is transferred to the next memory component: short-term memory (often called working memory) (3).

Consider short-term memory the mind's desktop. It is limited in the amount of information that it can process at any given time (7+ or −2 bits of information) (32). It is also limited in the amount of time (~30 s) that information is stored. Information in short-term memory is quickly lost if a learner doesn't do something with the information. The duration and effectiveness of information storage in short-term memory can be expanded by chunking, by repetition and rehearsal practices, and by managing cognitive load, referred to as all the mental resources activated or required when completing a task. If the appropriate techniques are applied in working memory, the information is transferred to long-term memory (3).

Consider long-term memory the storehouse of all personal data that have been consciously (and unconsciously) stored throughout an individual's life and experience. The storage appears unlimited. However, due to clear incidences of an inability to retrieve stored data (forgetting), the duration of storage is unclear. The ability to access information that hasn't been regularly retrieved will decay over time if the need to retrieve or the need to practice retrieving diminishes. Effective retrieval practices also diminish in cases when the presence of other information distracts from efforts to retrieve stored information.

Cognitive science has also provided a language for understanding how knowledge is stored. For example, concepts represent the most fundamental constructs in theories of the mind (28). Concepts serve as the building blocks for how learners determine what belongs together (categorization) (43). Concepts and categories are subsumed into larger data structures that represent the generic concepts stored in memory. According to schema theory, all data representing all concepts are represented in the mind as schemata (26). In short, knowledge and experiences, if stored in long-term memory, are stored within a deeply connected network (schema or schemata) that includes categories and concepts. These have also been referred to as propositions, units, and elements (2).

Anderson (2) refers to the encoding process as a trace, wherein information processed in working memory becomes a permanent memory structure in long-term memory. New information and experiences processed within working memory activate previously stored traces in long-term memory. As a result, working memory and long-term memory overlap in their contents. Anderson referred to this process as "spreading activation" and suggested that the speed and effectiveness of memory retrieval are based on the strength of the connections between what is being processed in working memory and the schema activated in long-term memory (2).

One method for enhancing memory storage and recall is organization (41). Since well-organized information already presents within a structure or network, it is easier to store. However, one of the most potent methods for increasing memory is to have students elaborate on the to-be-remembered material (2). In elaboration, students purposefully connect new information to information they already know (41). Another powerful approach, meaningful learning, uses both processes of organization and elaboration and presents the critical concepts and principles of the content first (2).

A variety of pedagogical tools have been derived from these information processing methods. For example, providing students with advanced organizers before the presentation of new material focuses student's attention on what is important. Advanced organizers can also trigger spreading activation processes and serve as the framework for organizing new material, allowing new content to be linked to previously learned material (4). Another learning tool, concept mapping, is the most recent method to be used among educators. Concept maps are graphical depictions of concepts connected by links that represent the relationship(s) between concepts. One way concept maps are used is to have students work individually or in small groups to build concept maps that depict their perceptions of the material. If used appropriately, concept maps can differentiate between students' knowledge (concepts) and understanding (nature and accuracy of the links between concepts) (23).

COMMENTARY: HOW DOES CURRICULUM DESIGN 3 EXEMPLIFY COGNITIVE LEARNING THEORY? This curriculum design includes pretests that require mastery of concepts learned in the physiology lecture course that all students completed the previous semester. The pretest both triggers and strengthens the spreading activation processes that access students' prior knowledge. The subsequent learning goal is for students to build traces that connect new material to material learned in the previous course(s). The basic concepts of new material are always presented first with more complex material progressively added to the basic conceptual structure. The use of cumulative posttests after each laboratory enhances long-term memory storage through the spreading activation process that accesses students' newly formed traces. The mastery learning approach ensures that students won't be exposed to more complex content until they've demonstrated progressive mastery over the fundamental knowledge needed to grasp more complex concepts and their relationships to each other.

The most overt leverage of cognitive learning theory in this design is the capstone assessment using concept maps. The concept maps represent student's conceptualization (schema) of the content so the teacher (and others) can see how the student has organized the knowledge in his or her own thinking about the content. Students' concept maps allow faculty members to assess the strength and complexity of the connection of concepts in students' long-term memory.

Curriculum design proposal 4. Learning theory: constructivism. Students are provided with a series of questions that should be answered during the semester, the range of

equipment and consumables they can use, and training on how to use them. For example, in one case, students are given pulse oximeters, spirometers, Douglas bags, peak flowmeters, and belts to record respiratory chest excursions and are challenged to discover the factors that determine the length of a breath hold. Students present an experimental hypothesis and design about which the faculty member provides feedback, perhaps suggesting some refinements. Students then perform their experiments and develop a written report. Students are graded on the process of experimental design, execution of the plan, physiological and conceptual interpretations of their results, and discussion about limitations of their design.

COMMENTARY: WHAT IS CONSTRUCTIVISM? Compared with previous theories of learning, a grasp of constructivist theory requires a substantial paradigm shift in beliefs about what constitutes knowledge, what reality is, what learning is, and how learning takes place. Before the constructivist movement, theorists assumed that there was a single external reality, a privileged point of view. The mind was viewed as a blank slate that passively copied what was presented. "Learning" and what constituted "knowledge" equated to the level at which individuals accurately acquired this "reality" (12). In contrast, what constitutes reality from a constructivist perspective is dependent on the "eye of the beholder." Knowledge is subjective and actively constructed as learners engage with, and make meaning of, their lived experience (12, 17).

The shift in what constitutes knowledge, learning, the nature of the mind, and how the mind works is largely due to Jean Piaget's research on children's cognitive development. According to Piaget, humans are inherently driven to organize thinking processes into psychological structures or "schemes." Exposure to new information and experience requires new schemes to be constructed and/or simple schemes are combined into more complex, more effective schemes. Piaget posited that cognitive development was the result of two processes, assimilation and accommodation. Assimilation processes are active when learners interpret new experiences based on existing schemes or use existing schemes in knowledge construction. Accommodation processes are activated when learners are exposed to new information or experiences that don't fit with existing schemes. In such cases, learners must redesign current schemes or construct new schemes. As such, in a constructivist perspective, activation of prior knowledge is critical to the learning process, since learners interpret their current experiences based on what they already know (10, 41).

The paradigm shift in beliefs about knowledge and how students learn introduced a subsequent shift in beliefs about teacher and student roles in the learning process. Previous instructional strategies wherein the teacher was the most active agent in the learning process shifted to student-centered instruction designed to actively engage the student in constructing personal knowledge. Constructivist teachers design instruction to encourage student ownership of the learning process. As often as possible, lessons are designed to take place in authentic environments where students are presented with complex, ill-solved problems. Lessons typically introduce experiences that challenge students' current suppositions. Teachers interact with students to discern their current level of understanding and point of view. This knowledge is subsequently used to respond and/or plan instruction to address students' remaining knowledge gaps or misconceptions (14, 41).

Discovery and experiential learning as well as inquiry-based and problem-based learning approaches, if implemented correctly, are representative of constructivist teaching approaches (27). While the benefits of students' active engagement in the learning process have been recorded (19, 21), these approaches are not without controversy (27). Still, the underlying principles of constructivism, that students construct knowledge via active engagement in their environment, allow for the use of creative instructional approaches. For example, Prakash (34) reported results of an instructional approach wherein students were presented with logical questions as they progressed through the traditional lectures. Students who were exposed to this approach (experimental group) did better on the posttest than students who were not exposed to this approach (control group). While the differences in students' scores were the same after 4 mo, the knowledge level of the experimental group had remained the same. In contrast, the control group had to close the knowledge gap in the 4-mo period (33).

COMMENTARY: HOW DOES CURRICULUM DESIGN 4 EXEMPLIFY CONSTRUCTIVISM? In this proposed laboratory curriculum, there is a major shift in the roles of teacher and learner. The teacher has provided a broad framework, set a problem to be explored, and made resources available for students to construct knowledge as they interact within an authentic environment. The learner has opportunities to try different approaches and make personal meaning of the results. Learning is goal driven as students try to solve, in this case, the imposed problem. Importantly, the learner is not just reacting to the fairly stringent guidelines and templates in previous models but is now interacting with the problem and environment. The keystones of constructivism are assimilation and accommodation. The development of initial hypotheses requires students to activate prior knowledge based on their existing schemes. As new information is obtained through experimentation, there will be a need for reevaluation and reformulation of prior schemes to accommodate new information.

Curriculum design proposal 5. Learning theory: social constructivism. Students are organized in teams of five to six students. In team formation, careful attention is paid to all aspects of diversity, including level of prior experience, sex, age, racial and ethnic backgrounds, etc. Each student group is challenged to reflect on the everyday experience of their own physiology and to prioritize three questions they would like to address during the semester. Groups are expected to meet outside of formal class time and to clarify roles. Several milestones are defined by faculty members to monitor the progress of the group toward the completion of the project and to provide feedback on goals and experimental designs and developing interpretations of the data. The student group performs their experiments and is graded based on a collaborative writing project for the report and a group oral presentation. The products are graded on the process of experimental design, execution of the plan, physiological interpretation of their results, and discussion about limitations of their design. Ten percent of the grade is based on a self- and peer evaluation about teamwork, professionalism, and quality of feedback to teammates.

COMMENTARY: WHAT IS SOCIAL CONSTRUCTIVISM? Lev Vygotsky's work is most frequently associated with sociocultural

theory and the social constructivism movement (29). Vygotsky viewed learning and development as a social process wherein learners "grow into the intellectual life of those around them" (38). As such, learning is a process of enculturation or appropriation, wherein learners gradually "internalize or take for themselves knowledge and skills they developed in their interactions with others and with cultural tools" (41).

From Vygotsky's perspective, knowledge exists on two levels: the interpersonal (external level) and the intrapersonal (internal level). Learners cannot gain the latter (internal) without reasonable exposure to the former (external) (38). According to Vygotsky, "semiotic mechanisms mediate social and individual functioning and connect the external and the internal, the social and the individual." Semiotic mechanisms can include any number of cultural tools, language, symbol systems, calendars, processes, art, maps, writing, writing utensils, technology, and machinery; essentially any tool, tangible or symbolic, that humans use to adapt and thrive within the context of their environment. Through exposure to and continued use of the cultural tools, real experience becomes symbolically represented in the mind and the external is internalized; appropriation takes place (25).

According to Vygotsky, the only "good learning" is learning that advances development. Vygotsky described two levels of development deemed essential for understanding the learning process: the "actual developmental level," best understood within the context of what learners understand or can do without assistance from someone with more knowledge or expertise; and the "zone of proximal development" (ZPD), or what the learner grasps or can do with guidance from a more knowledgeable other (38). Although Vygotsky likely identified the more knowledgeable other as a teacher or a peer, with the easy access to information afforded today's students, text, audio, and video can also support student learning. More knowledgeable others provide support and scaffold the knowledge or skill acquisition process for the learner. With adequate support provided at the ZPD, the learner eventually internalizes the target knowledge and skills and gains autonomy in his or her ability to understand and use the semiotic mechanisms (tools) of the culture.

Some of the recent reforms in education are a result of educators' attempts to implement principles of learning and development as presented in Vygotsky's work. For example, educators have implemented differentiated instruction models as one approach for dealing with the increasingly diverse student population in the typical classroom. Similar to principles of ZPD, differentiated instruction approaches consider and accommodate students' backgrounds, languages, readiness levels, interests, and learning profiles. Teachers serve as mentors who use appropriate techniques to help each student realize his or her learning potential. Students strive to become independent and self-sufficient in content related skills, abilities, and ideas (37). The introduction of various forms of peer and collaborative learning, as well as situated learning, are additional examples of instructional strategies that are based on social constructivist principles (41). In summary, social constructivist approaches to instruction focus on student learning rather than performance, support coconstruction of knowledge that is guided by more knowledgeable others, scaffold instruction to expand students' current understanding or skills, and are situated in authentic contexts wherein students are provided opportunities to use appropriate cultural tools and language (1, 39).

COMMENTARY: HOW DOES CURRICULUM DESIGN 5 EXEMPLIFY SOCIAL CONSTRUCTIVISM? This learning context is set within an authentic environment wherein students are encouraged to answer real-life questions that they have identified based on their own experiences. The assigned exercise provides students with opportunities to use and gain experience with the cultural tools (semiotic tools) typical to the discipline. The use of heterogeneous student groups insures diversity of thought, ability, prior knowledge, and experience, allowing students to provide expertise to the group in areas reflecting their strengths. The milestones serve as informal assessments that allow faculty members to determine the students' accuracy of understanding, misconceptions, or dysfunctional group processes. With this information, faculty members determine the group's optimal ZPD and scaffold next-step instruction to meet the particular learning needs of each student group. Depending on what the group needs to move to the next level of competence or understanding, faculty members may serve as the "more knowledgeable other," use other students within or across groups, supplemental readings, or web-based resources to provide developmentally appropriate support for each group.

Conclusions

This discussion was organized historically to present the theories and research that served to inform our current understanding of learning and to shape educational practice for more than half a century. Educators may be attracted to one theoretical approach based on their own experience as learners, and that approach may align well with the learning goals of their courses and curriculum. In this instance, a more comprehensive understanding of the principles and practices related to their theoretical approach allows for the strategic selection of pedagogical and assessment methods to enhance the efficiency and effectiveness of a learning encounter. However, with the recent initiatives to engage students in higher-order thinking and to build problem-solving and/or critical-thinking skills, there is often misalignment between an educator's preferred theoretical approach and course or curriculum learning goals. In this instance, educators are encouraged to review the various theories and to use an approach that suggests strong alignment with the target learning goals.

More recent theories of instructional design related to educational technology have not been included in this brief review as those warrant a discussion of their own. This omission has little to do with importance, since the growing influx of virtual learning spaces and the use of educational technology will make them critical to future educators. The impact of the interphase between technology, what previous generations of learners perceived as "real," and how the space between "real" and "virtual" is likely to merge for Millennials and the learners who come behind them is also likely to have significant impact on education. This, matched with the increasing speed of access to knowledge in most any discipline via technology, suggests that training in different skill sets may be needed in the work force of the future. While our understanding of learning and teaching may expand as the goals of education shift and new research and theories are presented, there is value

Table 1. *Summary of majory learning theories*

	Behavioral		Cognitive	Constructivist	
	Behaviorism	Social cognitive theory	Cognitive learning theory	Constructivism	Social constructivism
How learning is defined	Learning is defined by observable increases, decreases, or maintenance of identified behaviors.	Learning is defined by observable increases, decreases, or maintenance of identified behaviors.	Learning is an internal mental process that includes receiving, decoding, storing, and recalling information.	Learning is an individual construction process. Learners construct knowledge as they interact with their environment.	Learning is the internalization and adoption of external experience.
Principles	Behavior is understood based on the relationship between the stimulus and response. Behaviors can be influenced by controlling the stimulus and responses. There is no consideration of cognitive or affective components. The focus is purely on observable behaviors that are amenable to the stimulus-response relationship.	Principles of behaviorism apply. However, they are expanded to include the role of observational and vicarious learning. In other words, a learner doesn't have to be directly reinforced in order to demonstrate a behavior. Instead, a learner will or will not demonstrate (imitate) a behavior because he/she saw or heard what happened when someone else demonstrated the behavior. This theory also expanded to consider cognitive elements: • Extrinsic (but not intrinsic) motivation. • The role of retention, or remembering the required behavior and consequence. • A learner's beliefs about their ability to perform the behavior (self-efficacy). • A learner's self-regulation.	The mind is an information processor. Individuals form mental representations (schema or semantic networks) of lived experience (information, knowledge, episodes, relationships, and interactions). Experts have more complex semantic networks. Some learning experiences are more effective than others in insuring retention. Repetition and rote learning represent effective means for storing declarative knowledge when recall requirements are short term in nature. Learning experiences that use higher order thinking skills and connect new knowledge with prior knowledge structures (meaningful learning) have been associated with a deeper understanding of content and longer-term retention. Most all knowledge/learning is subject to decay and forgetting if not used with some frequency.	Learners construct new knowledge as they observe and interact with their environment. Most learners have prior knowledge or experiences they use to organize or make meaning of new information or experiences. Learning is goal driven, even if the goals are implicit and related to surviving or thriving in a given environment, satisfying natural curiosity, or solving a real or imposed problem. In its purest form, learning in this approach is nearly insidious. Knowledge and skills are developed due to frequent interactions and opportunities to experiment, try different approaches, organize concepts, make personal meaning, or integrate/synthesize concepts.	All learning is socially mediated. Learners develop knowledge and skills by their interactions with the tools, signs, symbols, and language in their environment. Optimal learning takes place within a learner's zone of proximal development, or the gap wherein a task represents an appropriate level of challenge given the learners' current skills, knowledge, and ability. Learners ″learn″ from any source that represents a useful, viable, and relevant source of information or support to meet the challenge. As such, any person or resource can serve as a ″more knowledgeable other.″ This ″other″ scaffolds the learning process, providing just the information or support needed to assist the learner with moving to the next level of understanding or skill. The ultimate learning goal is that the learner appropriates and internalizes the new information, tools, language, and skills.
Role of the teacher	The teacher plays a highly active role. The primary goal is to control the stimulus-response relationship in the environment. From obeying socially appropriate rules, to acting professionally, to achieving a passable score on an exam, the teacher adopting a behaviorist perspective will focus on identifying the types and schedules of reinforcement needed to insure the desired demonstration of the target behavior by the student at the desired time.	The teacher still plays an active role. There is still extensive focus on the environment, ensuring that both appropriate role models are used and stimulus-response mechanisms are reinforced. The primary role is the strategic use of imitation and control of the stimulus, response, and reinforcement relationships. The teacher optimizes the use of observational and vicarious learning. The teacher selects behaviors that learners can successfully perform. The teacher ensures that students are paying attention and see or hear about the consequences of desirable/undesirable behavior. The teacher provides both opportunities and adequate motivation for students to perform the desired behavior or to stop demonstrating undesirable behavior.	The teacher plays a highly active role to ensure that information is presented in an organized, well-structured manner and in chunks that can be appropriately digested by the learner in the time allowed. The defining concepts that are critical to deeper knowledge, understanding, and content related expertise are mastered before moving on to more complex, differentiated, or sophisticated content. Information is organized based on defining and discriminating features, with exemplars and nonexemplars provided so that learners can clearly differentiate examples and nonexamples. There is adequate repetition in increasingly sophisticated formats, from rote recall to utilization of higher order thinking (application, integration, and synthesis). The teacher builds semantic and conceptual networks through attention, repetition, or engagement of higher order cognitive tasks. Higher order cognitive tasks should require recall and deliberate practice, increase automaticity, and build complexity of cognitive knowledge structures.	While the teacher is still highly active in designing and facilitating learning encounters, the student is the most visibly active during the learning encounter. Since learning is a personal construction process, the teacher focuses on providing the necessary tools and opportunities for learners to accurately construct knowledge or skills.	The teacher adopting this perspective understands that all learning is social and uses both formal/informal resources to expand students' current level of knowledge, skill, and development. Learning encounters are designed so that learners face a challenge that aligns with their zone of proximal development and appropriate supports (more knowledgeable others, resources, and tools) are available to assist learners with meeting the challenge and moving to the next level of understanding or skill development. While the teacher may be the expert, his/her expertise, due to the level of sophistication or complexity, may not be the best source of learning and development for the student.

Continued

Table 1.—*Continued*

	Behavioral		Cognitive	Constructivist	
	Behaviorism	Social cognitive theory	Cognitive learning theory	Constructivism	Social constructivism
Role of the learner	The learner is a respondent: responds to the environmental stimulus.	The learner becomes more active in the learning process, although the concept of the learner is still one of a natural response to environmental stimuli. The learner pays attention to demonstrations (formal or spontaneous) of desirable or undesirable behavior. The learner remembers the desired/undesired behaviors. The learniner reproduces desired behaviors and decreases or stops undesirable behaviors.	Learners become more active as they must pay attention and attempt to retain and reproduce target knowledge and skills.	The learner still responds to the environment but the response is perceived in a different way. The response to the environment now is one of interaction versus reaction. The learner behaves in ways that achieve the desired outcomes, manipulates concrete and abstract concepts to make meaning, understands and solves problems, or achieves goals.	The learner uses the tools, signs, symbols, language, and more knowledgeable others to master the next level of understanding, knowledge, and/or skill. In some cases, learners can serve as the more knowledgeable other who can assist peers with learning goals.
Learning applications	From a practical perspective, behaviorism manifests in educational environments through awards for high performance, such as attention, praise, good grades, recognition, achievement awards, and access to opportunity; loss of privileges, scolding, suspension, disciplinary measures, or academic probation when students fail to consistently demonstrate desired behaviors represent penalties. Instructional constructs related to behaviorism include: • Direct instruction • Computerized instruction • Role of feedback • Timing of feedback • Student motivation (extrinsic) • Classroom management	Social cognitive theory is useful in understanding classroom management, socialization, and recognizing how strategic use of interactions with one learner can influence the behavior of other learners. It is also a highly useful theory when teaching a skill, especially using the process of attention, retention, motivation, and reproduction. This theory is the first among learning theories to consider cognitive explanations for learners' behavior. Constructs such as attention, retention, motivation, self-efficacy, and self-regulation highlight the learner's role in successfully demonstrating a given task. Instructional constructs related to social cognitive theory include: • Role modeling and imitation • Demonstration • Goal setting • Opportunities for practice • Strategic use of reinforcement	Cognitive learning theory is useful for learning well-organized constructs and principles that have clear exemplars and nonexemplars. Presentations of content should build on students' prior knowledge, be well organized, move from basic foundational constructs to more differentiated or complex constructs, and be limited to what learners can reasonably process in a given period of time. Processes like cognitive load and attention span are considered in determining how much content should be presented to learners in one sitting. Content is presented in ways that use memory aids and/or engage multiple senses (sight, sound, and touch) to enhance likelihood of memory storage. Adequate time is provided to learners to store information, and learners are given frequent opportunities for recall practice. Learning complex cognitive concepts and long-term retention are enhanced when students are provided with opportunities to meaningfully connect new knowledge to their existing knowledge structures. Instructional constructs related to cognitive learning theory include: • Memory aids • Advanced organizers • Meaningful learning • Individual and social opportunities to actively engage concepts and constructs	The impact of constructivism on education has been considerable. It shifted the role of the teacher from being the ″sage on the stage″ to being the ″guide on the side.″ The role of the learner shifted as well, from that of the passive recipient of information and behaviors that are modeled back for feedback and assessment to a highly active role in constructing one's own knowledge and developing skills based on experimentation and interaction with the learning environment. Instructional constructs related to constructivism include: • Active learning • Problem-based learning • The flipped classroom • Inquiry-based learning • Reflection	The impact of social constructivism and sociocultural theory has also been considerable in the last decade. The most obvious demonstration of this is in the increase of group work and group-based learning at all levels of education. Authentic learning activities wherein students are placed in ″real″ settings or presented with realistic cases, problems, or projects are another. Other manifestations of this perspective include the use of challenges and scaled learning, wherein complex learning goals are broken into stages, from basic or simple to more complex and sophisticated. Students master lower levels before being able to move up to higher levels of mastery. Instructional constructs related to social constructivism include: • Group projects • Group learning • Zigzag methods • Scaffolded learning goals • Peer tutoring and learning • Differentiated Instruction

in understanding the theoretical tools currently available to educators and how they can be applied to questions of today.

One final observation to consider–the basic principles of social constructivism, that all learning is socially mediated, is a result of interactions with cultural tools, and is shaped through guidance of more knowledgeable others–is evident in the previous theories (although not explicitly identified at the time). In behaviorism, culture determines what behaviors are sanctioned or unsanctioned as well as what reinforcing and punishing responses will shape the behavior. Bandura recognized the social aspect of learning via observational learning and noted that these stored experiences subsequently guided anticipatory behaviors in future interactions. Cognitive learning theory helped to explain how social knowledge and experiences are coded, retained, and recalled in human memory. Constructivism highlighted the active role of the learner in constructing their idiosyncratic reality based on their experiences; all of these principles are embedded within the specific context of "culture." All require interactions with the cultural norms, signs, symbols, and tools, and all require access to more expertise than the learner currently possesses. Therefore, to an extent, social constructivism subsumes earlier theories, and we regard it as the prevailing learning theory at the present time.

Physiology is a discipline. It has a culture of its own, with its own tools, language, symbols, processes, and assumptions. Faculty members who teach within this discipline represent the more knowledgeable other in terms of knowledge about physiology. The purpose of this work is to provide physiology

educators the opportunity to gain additional expertise in their role as physiology educators and to have a theoretical starting place for informing their classroom practice, instructional designs, and future research. The theoretically grounded physiology educator will find opportunities to leverage particular aspects of different learning theories to achieve the learning goals of their program and inform their educational scholarship. Table 1

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: D.K. and J.D.K. conception and design of research; D.K. and J.D.K. drafted manuscript; D.K. and J.D.K. edited and revised manuscript; D.K. and J.D.K. approved final version of manuscript.

REFERENCES

1. **Adams P.** Exploring social constructivism: theories and practicalities. *Education* 34: 243–257, 2006.
2. **Anderson JR.** A spreading activation theory of memory. *J Verb Learn Verb Behav* 22: 261–295, 1983.
3. **Atkinson RC, Shiffrin RM.** Human memory: a proposed system and its control processes. In: *The Psychology of Learning and Motivation*, edited by Spence KW, Spence JT. New York: Academic, 1968, vol. 2, p. 89–195.
4. **Ausubel DP.** Use of advance organizers in the learning and retention of meaningful verbal material. *J Educ Psychol* 51: 267–272, 1960.
5. **Bandura A.** *Self-efficacy: the Exercise of Control*. New York: W. H. Freeman, 1997.
6. **Bandura A.** Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev* 84: 191–215, 1977.
7. **Bandura A.** *Social Foundations of Thought and Action: a Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall, 1986, p. 391.
8. **Bandura A.** *Social Learning Theory*. Englewood Cliffs, NJ: Prentice-Hall, 1977, p. 391.
9. **Bandura A.** Social cognitive theory of self-regulation. *Organ Behav Hum* 50: 248–287, 1991.
10. **Bayles EE.** Theories of learning and classroom methods. *Theor Pract* 5: 71–76, 1966.
11. **Block J.** Assimilation, accommodation, and the dynamics of personality development. *Child Dev* 53: 281–295, 1982.
12. **Boekaerts M, Pintrich P, Zeidner ME** (editors). *Handbook of Self-Regulation*. San Diego, CA: Academic, 2000.
13. **Boghossian P.** Behaviorism, constructivism, and socratic pedagogy. *Educ Philo Theory* 38: 713–722, 2006.
14. **Bordage G.** Conceptual frameworks to illuminate and magnify. *Med Educ* 43: 312–319, 2009.
15. **Brooks MG, Brook JG.** The courage to be constructivist. *Educ Leadership* 57: 18–24, 1999.
16. **Clayton MC, Woodard C.** The effect of response cards on participation and weekly quiz scores of university students in introductory psychology courses. *J Behav Educ* 16: 250–258, 2007.
17. **Fincher RM, Simpson DE, Mennin SP, Rosenfeld GC, Rothman A, McGrew MC, Hansen PA, Mazmanian PE, Turnbull JM.** Scholarship in teaching: an imperative for the 21st century. *Acad Med* 75: 887–894, 2000.
18. **Flavell JH.** Piaget's legacy. *Psychol Sci* 7: 200–203, 1996.
19. **Flosason TO, McGee HM, Diener-Ludwig L.** Evaluating impact of small-group discussion on learning utilizing a classroom response system. *J Behav Educ* 24: 317–337, 2015.
20. **Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H, Wenderoth MP.** Active learning increases student performance in science, engineering, and mathematics. *Proc Natl Acad Sci USA* 111: 8410–8415, 2014.
21. **Glassick CE.** Boyer's expanded definitions of scholarship, the standards for assessing scholarship, and the elusiveness of the scholarship of teaching. *Acad Med* 75: 877–880, 2000.
22. **Hake RR.** Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. *Am J Phys* 66: 64–74, 1998.
23. **Hansen PA.** Sitting in the catbird seat. *Adv Physiol Educ* 25: 1, 2001.
24. **Hay D, Kinchin I, Lygo-Baker S.** Making learning visible: the role of concept mapping in higher education. *Stud Higher Educ* 33: 295–311, 2008.
25. **Irby DM.** What clinical teachers in medicine need to know. *Acad Med* 69: 333–342, 1994.
26. **John-Steiner V, Mahn H.** Sociocultural approaches to learning and development: a Vygotskian framework. *Educ Psychol* 31: 191, 1996.
27. **Kessen W, Ortony A, Craik F.** *Memories, Thoughts, and Emotions: Essays in Honor of George Mandler*. Hillsdale, NJ: Erlbaum, 1991.
28. **Kirschner PA, Sweller J, Clark RE.** Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educ Psych* 41: 75–86, 2006.
29. **Laurence S, Margolis E.** Concepts and cognitive science. In: *Concepts: Core Readings*, edited by Margolis E, Laurence S. Cambridge, MA: MIT Press, 1999, p. 3–81.
30. **Liu CH, Matthews R.** Vygotsky's philosophy: constructivism and its criticisms examined. *Int Educ J* 6: 386–399, 2005.
31. **Malanga PR, Sweeney WJ.** Increasing active student responding in a university applied behavior analysis course: the effect of daily assessment and response card on end of week quiz scores. *J Behav Educ* 17: 187–199, 2008.
32. **Martin J.** Self-regulated learning, social cognitive theory, and agency. *Educ Psychol* 39: 135–145, 2004.
33. **Miller GA.** The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychol Rev* 101: 343–352, 1994.
34. **Prakash ES.** Explicit constructivism: a missing link in ineffective lectures? *Adv Physiol Educ* 34: 93–96, 2010.
35. **Schunk DH.** Self-efficacy and achievement behaviors. *Educ Psychol Rev* 1: 173–208, 1989.
36. **Shuell TJ.** Cognitive conceptions of learning. *Rev Educ Res* 56: 411–436, 1986.
37. **Stephens TM.** Directive teaching in the classroom. *Theor Pract* 13: 91–96, 1974.
38. **Subban P.** Differentiated instruction: a research basis. *Int Educ J* 7: 935–947, 2006.
39. **Vygotsky LS.** *Mind in Society: the Development of Higher Psychological Processes*. Cambridge, MA: Harvard Univ. Press, 1978, p. 88 and 192.
40. **Watson J.** Social constructivism in the classroom. *Support Learn* 16: 140–147, 2001.
41. **Wood R, Bandura A.** Social cognitive theory of organizational management. *Acad Manage Rev* 14: 361–384, 1989.

41a. **Wilkerson L, Irby DM.** Strategies for improving teaching practices: a comprehensive approach to faculty development. *Acad Med* 73: 387–396, 1998.

42. **Woolfolk A.** *Educational Psychology* (11th ed.). Boston, MA: Pearson, 2011, p. 377.
43. **Woolfolk Hoy A, Davis HA, Anderman EM.** Theories of learning, and teaching in TIP. *Theor Pract* 52: 9–21, 2013.
44. **Zentall TR, Galizio M, Critchfield TS.** Categorization, concept learning, and behavior analysis: an introduction. *J Exp Anal Behav* 78: 237–248, 2002
45. **Zimmerman BJ, Schunk DH.** (editors). Albert Bandura: the scholar and his contributions to educational psychology. In: *Educational Psychology: a Century of Contributions*. New York: Erlbaum, 2003, p. 431–458.
46. **Zimmerman BJ.** Self-regulated learning and academic achievement: an overview. *Educ Psychol* 25: 3–17, 1990