A Primer for the Application of Cognitive Learning Principles to Pharmacy Teaching and Learning

Douglas J. Lynch
David F. Maize

ABSTRACT. This paper reviews the utility of cognitive and educational psychology to improve pharmacy teaching and learning. Emphasis is placed upon the formation of cognitive schema, development of expertise, transfer of learning and metacognitive skills. Using these few principles, students' motivation to learn should increase and make them lifelong learners while improving pharmacy teaching. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800- HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: <http://www.HaworthPress.com> © 2006 by The Haworth Press, Inc. All rights reserved.]*

KEYWORDS. Cognitive schema, transfer of learning, expertise, metacognition, pharmacy curriculum

INTRODUCTION

Cognitive and educational psychologists have provided useful theories and applications for educational curricula, teaching strategies and assessments; however, our review of pharmacy journals found few published articles that explicitly relate cognitive and educational psychology to

Douglas J. Lynch, Ph.D., is Associate Professor in the Department of Education, Wilkes University, 84 West South Street, Wilkes-Barre, PA 18766.
David F. Maize, R.Ph., Ph.D., is Associate Professor and Associate Dean, Feik School of Pharmacy, University of the Incarnate Word, 4301 Broadway Street, San Antonio, TX 78209. At the time the manuscript was prepared Dr. Maize was with the Nesbitt College of Pharmacy and Nursing at Wilkes University.

Journal of Pharmacy Teaching, Vol. 13(1) 2006
Available online at http://www.haworthpress.com/web/JPT

doi:10.1300/J060v13n01_02

pharmacy teaching. To make pharmacy students better learners and improve teaching strategies for faculty, this paper addresses the development and utility of cognitive schema, the development of expertise, transfer of learning and metacognitive processes. This primer reviews some studies to familiarize pharmacy faculty with typical cognitive research and provide examples of their use in a pharmacy program.

FORMATION OF LONG-TERM MEMORY

Some pharmacy programs and practices are erroneously constructed from the "package" metaphor of teaching and learning. This design suggests that knowledge and skills offered at one level or course is stored intact, to be retrieved later upon demand. It is quite common that didactic material that is taught in the early years of a pharmacy curriculum is expected to be retrieved intact during advanced practice experiences. The package metaphor largely ignores key research that cognitive psychologists have conducted in the past twenty years. This research shows that cognitive processes are very dynamic. Instead of storing messages, information and experiences intact, students solve problems based upon an active process of interpreting new information in light of what is already known.

An example of this was shown by Bartlett (1) et al. They investigated long-term memory formation by presenting participants with information and then assessing their recall at various time intervals. Adults read a folk tale and recalled it immediately, after three months and after one year. The results showed that the subjects not only forgot information from the folk tales that did not make sense to them, but also added information that was never in the original passage. There were notable patterns in what was recalled as the time interval increased, which seemed to match patterns of the adults' prior experience. This early experiment provided evidence that long-term memory consists of an active construction process and uses prior knowledge in the recall of learned information. These "packages" of knowledge are placed into schemas which become distorted over time and constantly need to be assessed and reinforced.

SCHEMA

Across a wide array of learned content, research has demonstrated that information in our long-term memory is organized into "schema." Schemas are knowledge structures that represent repeated patterns of experiences (cognitive as well as behavioral). These actively formed structures consist of long-term memory "slots," with each slot holding a place for distinctive features of the repeated experience. It is like putting knowledge and behaviors into mail slots. Each mail slot is a destination that facilitates recall. Dooling and Lachman (2) demonstrated this by merely presenting a title to an ambiguous passage before reading the passage. The title activated the reader's schema. Subjects who were given the title recalled significantly more of the passage than those who did not know the title. Once a schema is constructed, students can process stimuli rapidly and accurately, recall prior learning experiences, and act upon incomplete information in a predictable manner.

Schema use past memories to dictate future behavior. An example of a behavioral schema would be riding a bicycle. Once a person learns to ride a bicycle, they can get on any two-wheel vehicle and have a good chance of riding it successfully even though they have not ridden it before. A practical application of this concept is seen in the Self Care module of Pharmacotherapeutics at the Nesbitt School of Pharmacy. The QuEST Scholar technique is taught to the students so they can recommend over-the-counter products (OTC). This technique uses a mnemonic device in which each letter represents a different question to ask a patient. After continued practice, the students develop a schema to answer OTC questions. In subsequent courses, advance practice experiences or after graduation, they can listen to the patient's problem, ask questions to gain additional information and then make a sound recommendation on an OTC product or refer the patient to another health care provider.

Schemas also allow students to correctly act upon incomplete information to maximize their cognitive efficiency by facilitating inferencing. For example, if a student had a well-developed schema for self-care of dermatology, and then was confronted with an incomplete case presenting itself as a rash, they should readily infer the symptomology and the medications that would be most useful to the patient. Therefore, schema affects perception, recall and inferential processing (1-3). The student could quickly determine, in this example, that the patient has an itchy poison ivy rash, and could recommend appropriate OTC therapy for this case. As students become more proficient in using their schema, they develop an expertise in an area.

EXPERTISE

Psychological development research provides insights into expertise in adults. The study of expertise helps in the understanding of the relationship between acquiring knowledge and skills and application of those skills to a specific context. The typical research paradigm requires experts and non-experts to recall or respond to information or an experience that is both within their area of expertise and outside. The typical results show that experts excel within their domain but not outside. For example, physics experts and college students were asked how they would solve physics problems. The experts consistently referred to principles appropriate to the problem, the rationale for the principles and how the principles could be applied. Non-experts, i.e., college students, did not rely upon such organized knowledge, but described equations they would use and how to solve the equations (4, 5).

In another study that showed that experts organize their knowledge by principles whereas novices organize by surface features, Chi, Feltovich and Glaser (6) showed that physics experts sorted problems, written on index cards, according to the principles needed to solve the problems such as the principle of the conservation of energy. The novices in the study focused only on the problems instead of the principles needed to solve the problem. With pharmacy students, a novice tends to focus on one drug, disease and mechanism at a time in a patient's case while a more advanced student views the whole patient and all the interactions with drugs and medical conditions. An expert or mature learner applies their knowledge wholly to a problem unlike a novice learner that applies knowledge linearly or step by step to problems.

Initial cognitive research examined developmental differences between children and adults. Children routinely recall far less than adults when they respond to memory tests. Psychologists initially thought this meant that children have less cognitive capacity or less space to store memories. However, researchers demonstrated notable difference in cognitive patterns when asked to perform memory tasks within a typical childhood knowledge area. Chi (7) set up an experiment in which adults and children briefly observed chess pieces in either randomly placed positions or placed during a chess game, and then the pieces were removed from the board. The task was to put the chess pieces back in their correct position. Adults without chess experience were compared to 10-year-old chess experts. The 10-year-olds were much better in replacing the chess pieces representing a chess game, but performed at significantly lower levels when recalling the randomly placed pieces. The key point found in this experiment was that expertise is context dependent. Experts apply higher-level thinking skills within relatively narrow domains of knowledge. Such experts depend upon schematic patterns to systematically process and act upon stimuli in a very efficient manner

(8). Expertise research is rich with examples from diverse areas such as physics (9), radiology (10) medicine (11), chess (12) and figure skating (13). These studies demonstrated that experts exhibit several valuable characteristics. They notice features and patterns that novices miss, have organized networks of schema that represent information in depth, can recall information with little effort or attention and approach challenging situations with flexible strategies (3).

Experts have been "conditioned" to recognize the contexts in which to apply their knowledge and skills. Bransford, Brown and Cocking (3) noted, "Expert's knowledge cannot be reduced to sets of isolated facts or propositions but, instead, reflects contexts of applicability: that is, the knowledge is 'conditionalized' on a set of circumstances." To conditionalize or to make experts out of students, pharmacy knowledge and skills must be developed in applicable contexts.

INSTRUCTIONAL IMPLICATIONS OF SCHEMAS AND EXPERTISE

To develop schemas and expertise in the practice of pharmacy, readings, lab experiences and lectures should be organized to emphasize the distinctive features and patterns necessary for learning pharmacy content and skills. Schemas will form by students recognizing these patterns through numerous examples. Instructors should present examples drawn from their respective pharmacy fields, asking students to focus their attention on the distinctive features of those examples. These carefully structured learning experiences should be distributed over several semesters.

Faculty should teach skills with "pedagological content knowledge" or stated another way, knowledge of how to teach the content. Pharmacy faculty may know the content but may not know how to teach the content. If the faculty member does not know how to teach a subject or lacks pedagogical content knowledge, it is difficult for the student to develop expertise in the field. The student cannot correctly put knowledge and behaviors into schema to use later. Strong pedagogical content knowledge suggests to the instructor common challenges students have in learning the topic and how to help them address these challenges through curriculum and instructional strategies (14-16).

Students should be checked to see if they can differentiate between correct examples and similar non-examples. In the context of a therapeutics course, this can be as simple as classifying medications into their proper pharmacological class. Even though ceftizoxime, ceftriaxone and cefuroxime are all cephalosporins, each one has its own uses and dosage forms. Students need to differentiate between them and understand that one is the correct example and the others are similar non-examples when applied to a patient's case.

It is important that faculty inquire about students' prior knowledge before teaching new information. Instructors need to look for misinformed beliefs and shifts in emphasis and distortion of knowledge. As stated before, long-term memory distorts with time. These misunderstandings may interfere with the students' development of their expertise in an area, which decrease their efficiency and accuracy to solve problems.

Early identification of erroneous beliefs and skills is essential to prevent students forming incorrect schema that may be quite resistant to change. Well-formed schema are automatically processed and thus largely unconscious (17). Students may overcome erroneous schema by first recognizing their errors and then using self-assessments to monitor their future thinking.

CONCLUDING REMARKS ON SCHEMA AND EXPERTISE

Cognitive processes are very dynamic. Learning and recall from long-term memory is organized into schema, and experts have well-developed knowledge networks that increase their accuracy and efficiency. Instructors should continue to develop students' schemas and check for disbeliefs on a frequent basis. Giving multiple examples in a topic, allowing the students to practice and providing constructive feedback help the student develop their schema and expertise in a field. This is extremely important in making a student a lifelong learner. Solving problems cannot be overemphasized here. Giving students many opportunities to practice and think independently will help them solve problems that they are confronted with later. To facilitate student learning, it is more important to allow the students to apply knowledge than it is to simply give it to them.

TRANSFER OF LEARNING AND METACOGNITION

The focus of several areas of cognitive research is to improve students' lifelong learning and study strategies. Research on transfer of learning and metacognitive processes provides clear principles on improving learning and studying.

TRANSFER OF LEARNING

Transfer of learning is defined as the learning of ideas and skills in one context and demonstrating them in another (18). Transfer of learning may be within the same course, in a different course or after graduation. Quite often, first year pharmacy students are taught a technique or method and are expected to it use again throughout pharmacy school. Even though some of these students do well in the course, they act as if they have forgotten the concept when asked to apply it to another course.

Academic requirements that seem reasonable and are designed to foster transfer are not always effective. For example, many years ago, Latin was a popular subject in high school. At that time, the rationale for studying Latin was to develop mental discipline of the mind, a type of cognitive skill that would be useful in other classes and postsecondary education. However, there is little research evidence for general transfer of cognitive skills. Specifically, learning Latin does not help with problem solving or logic (19), but it may help make learning other similar languages or words easier. Transfer of learning and its utility should not be overextended.

In an early experiment investigating transfer of learning, Hendrickson and Schroeder presented participants with two different learning contexts. They were investigating which contexts lead to learning in a new situation. In the study, the accuracy of throwing darts at an underwater target was measured. One group only practiced dart throwing at a target submerged 12 inches underwater. The second group received an explanation of refraction of light and practiced throwing underwater at the same distance. Both groups did equally well when the target was in 12 inches of water. But when the water depth was changed to 4 inches, the group that had learned the principles of refraction was significantly more accurate. The second group could transfer the knowledge they learned to a new situation (20). This example could be applied to pharmacy education. For example, if pharmacy students were only required to memorize the FDA-approved indications for the top two hundred drugs without learning the mechanism of action of these drugs, they would not be able to reason why a drug was used for a non-indicated use.

Although transfer of learning is very context specific, research suggests four instructional principles for improving transfer. First, transfer is enhanced when there are similar features between the original learning context and the context in which the knowledge or skill are to be applied (21). Second, teaching topics in considerable depth is preferable to teaching many cursory topics (22). Third, learning a variety of examples and practicing skills helps facilitate transfer (3, 23). Fourth, transfer is improved by emphasizing principles rather than mere factual recall (24).

To allow the student to practice transfer of learning, ask them to solve a problem after learning the correct response in a related content. For example, "What are the medications of choice for a patient with Type II diabetes?" "What if the patient had an allergy to sulfonylureas?" Another approach to help the student transfer learning would be to propose solutions to a whole set of related problems that have similar abstract qualities. Using a similar example of the sulfonylurea allergy, a student is given a case in which the patient has this allergy. In the patient's medication list, there would be drugs that contained sulfa groups in them. The student would have to transfer their knowledge about medicinal chemistry and sulfa allergy to determine if the patient could take certain drugs. These approaches focus on relationships and patterns across different examples.

Learning principles are far more important than memorizing isolated facts. The importance of learning abstract associations rather than isolated facts was illustrated by Singley and Anderson (25). In this study, students learned algebra word problems about mixtures. The first group was presented problems using pictures to help them learn separate component skills, but without any exposure to relevant mathematical principles. The second group was presented the problems in tabular form that drew their attention to underlying mathematical principles. Students who learned the abstract principles were able to transfer their skills to novel word problems, but those who learned only the component skills were unable to do so. Over time, these mathematical representations become schema which was discussed previously.

Faculty may become more proficient at structuring transferable learning experiences through careful assessment. One method to assess the extent to which students transfer learning is called "graduated prompting" (26, 27). This method counts the number and types of prompts that are required before learners transfer their knowledge. Some learners may respond with a general prompt such as: "Can you think of something you learned earlier related to this problem?" Others may need more explicit prompting. This can be easily seen in pharmacy students on advanced practice rotations. Students who are able to transfer "book" knowledge to patient care will need little prompting when faced with a problem. Academically weaker students will require more prompting from the practitioner about information learned earlier in the program before they can successfully solve the patient's problem.

If the students are given a good foundation and can transfer learning, they will be able to apply material outside of the classroom from one problem to another. Pharmacy topics should be taught with prototype drugs, diseases or reactions and then more specific examples can be used to demonstrate these ideas. Transfer of learning lends itself to many active learning exercises such as case studies or role playing.

INSTRUCTIONAL IMPLICATIONS OF TRANSFER OF LEARNING

To facilitate transfer of learning, faculty in upper-level pharmacy courses should meet with those in lower-level courses to examine their topics and assignments. They should identify principles and a common vocabulary that will help students see connections between topics at different levels. Faculty should regularly require students to use information from previous courses in their current semester assignments.

Collaboration and integration is key to this process. Pharmaceutical Science faculty and Pharmacy Practice faculty must collaborate to make transfer of learning work well. Even better is when the scientists and clinicians can teach together. This way, students, hopefully, can see the foundations based in science and the utility based in practice.

METACOGNITION

Building schema, developing expertise and transferring knowledge is facilitated when students assume greater responsibility for their learning. Unfortunately, many students graduate high school with excellent grades and little awareness of how to rise to the challenge of demanding college-level work. Research shows that academically challenged students are often unable to use their metacognitive skills (28). Metacognition is defined as self-awareness and control over one's cognitive processes (29). Our experience is that academically weaker students attend class, but may not take notes. Even if they do not understand, they do not ask questions, and do not notice significant errors in their papers. Because their study habits worked for them before college, they fail to adjust their study strategies to meet college-level goals and expected performance; hence, they are not able to succeed in the prepharmacy or pharmacy curriculum. There was one study that assessed the metacognitive skills of pharmacy students. In a study by Lonie and Dolinsky, they showed that pharmacy students can self-reflect on negative behaviors; however, the researchers did not relate this to the students' study habits (30).

Effective metacognitive processing occurs when a student reads and rereads a section because they know that they did not comprehend the material. Students demonstrate metacognitive skills by being aware of the quality of their learning, attending to how they are studying and making adjustments if their initial strategies are not working. Fortunately, metacognitive awareness and processing can be learned. Teaching study strategies may help students become more aware of their thinking and more accurate judges of their academic work. This area of research provides optimistic examples of how weak students may rapidly improve their performance (31-35). The research team of Palinscar and Brown conducted several studies demonstrating the effectiveness of "reciprocal teaching." Students improved their reading comprehension skills by modeling their teacher. The teacher initially asked comprehension questions to promote summarizing, questioning and clarification of the reading exercise. Students then took over this role which led to their independent monitoring or self-assessment of their own comprehension, i.e., metacognition (36-38).

INSTRUCTIONAL IMPLICATIONS OF METACOGNITION

There are a number of strategies that can be used to improve student learning. One, using colored markers is a common way for students to study their texts, but they should select a few main ideas from their texts rather than excessively painting their books. This encourages deeper understanding by drawing their attention to the organization of ideas and relative importance of those ideas. Two, they could keep journals of their study habits and strategies remarking on how well they worked. Three, a very important metacognitive skill is to review the feedback from an instructor to prevent continued mistakes. Four, professors may also model metacognition by "thinking out loud" as they teach critical knowledge and skills.

CURRICULAR IMPLICATIONS OF COGNITIVE LEARNING PRINCIPLES

Planning and implementing a curriculum in a pharmacy program should utilize the theories presented in this paper regarding cognitive schemas, expertise and transfer of learning. Faculty should use a common vocabulary and principles that extend across semesters and between clinical and scientific divisions. Many examples that are based on specific pharmacy principles should be used and foundational scientific and clinical principles need to be repeated throughout the program. Assessment of schemas is needed periodically to prevent misinformation and reinforce ideas and techniques. For example, the Nesbitt School of Pharmacy uses the Pharmacist-Patient Consultation Program (PPCP). This is initially taught in the first year, and the students are expected to use it throughout the program. By their third year, they have used the "3 prime" questions (What were you told the medication is for?; How were you told to take the medication?; What were you told to expect?) so often that it becomes routine. Since there is one method of counseling being taught, the upper-level students can focus on the medical problems of the case and then automatically counsel the patient. This is a good example of schemas, expertise and transfer of learning being used together. They need to use all of these skills to successfully counsel a patient with a complex medical problem. Then they can self-assess their counseling to improve it. This would be an example of using metacognitive skills.

Prepharmacy courses should include the teaching of metacognitive techniques. If a prepharmacy program exists in the university, early intervention needs to be made with struggling students. The prepharmacy majors accepted into a university probably have strong academic credentials but may not have the study skills to succeed or meet their true potential in pharmacy school. These students do not suddenly become "smart" when they are accepted into the pharmacy program. Students will probably struggle throughout their pharmacy school career. Assessment data from the Nesbitt School of Pharmacy demonstrate this point. Prepharmacy students' GPAs statistically correlated with their graduating GPA ($r = 0.601$, $p < 0.05$) and the GPA of the first professional year was highly correlated with the final professional program's GPA ($r = 0.904$, $p < 0.05$). This implies that the GPAs change little from the beginning to the end of the program.

CONCLUSION

In this paper a number of principles were highlighted, which drew from cognitive and educational psychology. The paper has also presented several examples of cognitive research that may be readily adapted to pharmacy education. Future studies may investigate characteristics of pharmacy schema, alternative ways to enhance transfer of learning within a pharmacy content and skills and new approaches for assessing and documenting expertise. The purpose was to stimulate faculty to talk with each other, to examine their teaching practices, identify schema within their fields and enhance transfer of learning.

Two other areas of research that are beyond the scope of this paper but that hold promise for improving pharmacy education are learning styles and motivation to learn. Research investigating learning styles emphasizes both identifying individual differences and adapting instruction to those differences (39). Motivation to learn research investigates the interaction between motivational beliefs and how students respond to academic challenges (40, 41).

Addressing pharmacy curriculum and instruction in light of cognitive and educational psychological principles will raise issues of scope and sequence that is aligned to the student learning processes. This should greatly increase the students learning, make them lifelong learners and improve teaching. Pharmacy faculty will clearly benefit from discussions concerning the implications of cognitive and educational psychology to pharmacy education.

Received: September 16, 2005
Reviewed: October 28, 2005
Revised: January 23, 2006
Reviewed and Accepted: February 7, 2006

REFERENCES

1. Bartlett FC. Remembering: A study in experimental and social psychology. London: Cambridge University Press. 1932.

2. Dooling DJ, Lachman R. Effects of comprehension on retention of prose. *J Exp Psychol*. 1971; 88: 216-222.

3. Bransford J, Brown A., Cocking, R. eds. How people learn: Brain, mind, experience, and school. Washington, DC: National Academy Press. 2000.

4. Larkin JH, Enriching formal knowledge: A model for learning to solve problems in physics. In Anderson, JR. ed. Cognitive skills and their acquisition. Hillsdale, NJ: Erlbaum. 1981: 311-334.

5. Larkin JH, The role of problem representation in physics. In Gentner D, Stevens AL, Mental models. Hillsdale, NJ: Erlbaum. 1983: 75-98.

6. Chi MTH, Feltovich PJ, Glaser R. Categorization and representation of physics problems by experts and novices. *Cog Sci.* 1981; 5: 121-152.

7. Chi MTH. Knowledge structures and memory development. In Siegler, RS. ed. Children's thinking: What develops? Hillsdale, NJ: Erlbaum. 1978: 78-96.

8. Chi MTH, Glaser R, Farr M. eds. The nature of expertise. Hillsdale, NJ: Erlbaum. 1988.

9. Larkin JH, Understanding problem representations and skill in physics. In Chipman SF, Segal JW, Glasser, R. eds. Thinking and learning skills. Hillsdale, NJ: Erlbaum; 2: 1985: 145-59.

10. Lesgold AM, Rubison H, Feltovich P, Glaser R, Klopfer D. Expertise in a complex skill: Diagnosing X-Ray pictures. In The nature of expertise, Chi MTH, Glaser R, Farr M, eds. Hillsdale, NJ: Earlbaum 1988: 311-342.

11. Elstein AS, Shulman LS, Sprafka, SA. Medical problem solving: An analysis of clinical reasoning. Cambridge, MA: Harvard University Press; 1978.

12. Charness, N. Expertise in chess: The balance between knowledge and search. In Ericsson KA, Smith J. eds. Toward a General Theory of expertise, Cambridge, England: Cambridge University Press 1991: 39-63.

13. Deakin JM, Allard F. Skilled memory in expert figure skating. *Mem Cogn*. 1991; 19: 79-86.

14. Redish, EF. Discipline-specific Science Education and Educational Research: The Case of Physics. Paper prepared for the Committee on Developments in the Science of Learning for the Sciences of Science Learning: An Interdisciplinary Discussion. 1996: 19.

15. Shulman L. Those who understand: Knowledge growth in teaching. *Educ Res.* 1986; 15(2): 4-14.

16. Shulman L. Knowledge and teaching: foundations of the new reform. *Harv Educ Rev*. 1987; 57: 1-22.

17. Phye, GD. Practice and skilled classroom performance. In Phye G, Andre T. eds. Cognitive classroom learning: Understanding, thinking and problem solving. San Diego, CA: Academic Press.1986: 141-168.

18. Mestre, J. Transfer of Learning: Issues and Research Agenda. Report on the Workshop held at the National Science Foundation. 2002 March. Avaliable from http://www.nsf.gov/pubs/2003/nsf03212/nsf03212_1.pdf

19. Perkins DN, Salomon G. Are cognitive skills context bound? *Educ Res*. 1989; 18(1): 16-25.

20. Hendrickson G, Schroeder WD. Transfer of learning to hit a submerged target. *J Educ Psychol* 1941; 32: 205-213.

21. Royer JM. Theories of the transfer of learning. *Educ Psychol.* 1979; 14: 53-69.

22. Bransford J, Schwartz D. Rethinking transfer: A simple proposal with multiple implications. In Iran-Nejad A, Pearson P. eds. Review of research in education. Washington, DC: American Educational Research Association; 1999; 24: 61-100.

23. Gick M, Holyoak K. The cognitive basis of knowledge transfer. In Cormier S, Hagman J. eds. Transfer of learning: Contemporary research and applications. San Diego, CA: Academic Press. 1987: 85-108.

24. Anderson JR, Reder LM, Simon, HA. Situated learning and education. *Educ Res*. 1996; 25 (4, May): 5-96.

25. Singley K, Anderson JR. The transfer of cognitive skill. Cambridge, MA: Harvard University Press. 1989.

26. Campione J, Brown AL. Linking dynamic assessment with school achievement. In Lidz CS. ed. *Dynamic assessment:* An interactional approach to evaluating learning potential. New York: Guilford 1987: 82-114.

27. Newman D, Griffin P, Cole M. The construction zone: Working for cognitive change in school. New York: Cambridge University Press. 1989.

28. Hiebert E, Raphael T. Psychological perspectives on literacy and extensions to edu cational practice. In Berliner D, Calfee R. eds. Handbook of educational psychology. New York: Macmillan; 1996: 550-602.

29. Eggen P, Kauchak D. Educational psychology: Windows on classrooms. Upper Saddle River, NJ: Pearson: Merrill Prentice Hall. 2004.

30. Lonie, JM and Dolinsky, D. Enhancing metacognitive skills using written narratives: an analysis of pharmacy student's negative health behaviors in a behavior pharmacy class. *Am J Pharm Educ.* 2002; 66: 273-276.

31. Rosenshine, B. The case for explicit, teacher-led, cognitive strategy instruction. Paper presented at the annual meeting of the American Educational Research Association. Chicago, IL; 1997 Mar 26.

32. Renkl A., Stark R, Gruber H. Learning from worked-out examples: The effects of example variability and elicited self-explanations. *Contemp Educ Psychol*. 1988; 23:90-108.

33. Kurtz BE, Borkowdki JG. Development of strategic skills in impulsive and reflective children: A longitudinal study of metacognition. *J Exp Child Psychol*. 1987; 43:129-48.

34. Palincsar A, Brown A. Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cogn Instr*. 1984; 2:117-75.

35. Paris SG, Cross DR, Lipon MY. Informal strategies for learning: A program to improve children's reading awareness and comprehension. *J Ed Psych.* 1984; 76: 1239-52.

36. Palincsar A, Brown A. Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cogn Instr*. 1984; 2:117-75.

37. Palincsar AS, Brown A. Classroom dialogues to promote self-regulated comprehension. In Brophy J. ed. Advances in research in teaching (Vol. 1). Greenwich, CT: JAI Press: 1989.

38. Palincsar AS, Herrenkohl LR. Designing collaborative contexts: Lessons from three research programs. In O'Donnell AM, King A. eds. Cognitive perspectives on peer learning. Mahwah, NJ: Earlbaum. 1999: 151-177.

39. Snow R, Corno L, Jackson D. Individual differences in affective and conative functions. In Berliner D, and Calfee R. eds Handbook of educational psychology. New York: Simon & Schuster Macmillan. 1996: 243-310.

40. Stipek D. Motivation to learn: Integrating theory and practice. Boston: Allyn and Bacon. 2002.

41. Pintrich PR, Schunk DH. Motivation in education: Theory, research, and applications 2nd ed. Upper Saddle River: Merrill. 2002.