AFRICAN SOCIAL AND EDUCATIONAL JOURNAL
FACULTY OF BUSINESS ADMINISTRATION
IMO STATE UNIVERSITY
NIGERIA
VOL. 9 NO.3 SEPTEMBER 2020

LEARNING AND PROBLEM SOLVING: THE USE OF PROBLEM SOLVING METHOD TO ACHIEVE LEARNING IN PUPILS

IYAGBA, P. W.
Department of Educational Psychology, Guidance and Counseling
Faculty of Education
Ignatius Ajuru University of Education
P.M.B. 5047, Rumuolumeni
Port Harcourt, Rivers State

ABSTRACT

Problem-based learning is a recognized teaching method in which complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. Problem solving is a type of learning and is the pinnacle of Gagne's hierarchy of learning process and it depends on stimulus response learning, chain learning, verbal association learning, discrimination learning, learning of concepts and learning of principles. Problem solving necessitates the study of evidence and concepts in order to establish cause effect relationships of environmental phenomena. Educational psychologists are of the view that learning is much deeper than memorization and information recall. Deep and long lasting learning involves, understanding, relating ideas and making connections between prior and new knowledge, independent and critical thinking and ability to transfer knowledge to new and varied contexts. This study therefore will investigate the strategies for problem solving as it applies to the teaching-learning process.

Keywords: Learning, Problem Soving, Pupils.

Introduction

Educational researchers agree that learning is much deeper than memorization and information recall. Deep and long-lasting learning involves understanding, relating ideas and making connections between prior and new knowledge, independent and critical thinking and ability to transfer knowledge to new and different contexts. Encyclopedia Britannica defines Learning as the alteration of behaviour as a result of individual experience. When an organism can perceive and change its behaviour, it is said to learn. Iyagba (2020) views learning as a process through which desirable improvements are made in children's behaviour. It is a key goal of school and education which starts at the time of a child's birth and lasts until his death. Ambrose et al, (2010) posit that learning is "a process that leads to change, which occurs as a result of experience and increases the potential for improved performance and future learning" The change in the learner may happen at the level of knowledge, attitude or behavior. As a result of learning, learners come, to see concepts, ideas, and/or the world differently.

Learning is not something done to students, but rather something students themselves do. It is the direct result of how students interpret and respond to their experiences. While there are disciplinary differences in what students learn, it is important to keep in mind that learning content or information constitutes only one part of learning in students. Regardless of the field of study, students need to have significant opportunities to develop and practice intellectual skills/thinking processes such as; problem-solving, scientific inquiry, motor skills and attitudes/values that are important to their fields of study. The array of learned behaviour includes discrimination learning (where a subject learns to respond to a limited range of sensory characteristics, such as a particular shade of coloration), habituation (the cessation of responses to repeated stimulation), concept formation (the process of sorting experiences according to related features), problem solving, perceptual learning (the effects' of past experience on sensory perceptions), and psychomotor learning (the development of neuromuscular patterns in response to sensory signals). Association, conditioning, imitation, insight, and imprinting represent other types of learning.

Literature Review

There's more than one way to solve a problem. The five most common methods are; trial and error, difference reduction, means-ends analysis, working backwards, and analogies. Problem solving learning is a part of active learning which is "a method of learning in which students are actively or experientially involved in the learning process and where there are different levels of active learning, depending on student involvement." (Duch et al., 2001). Bonwell & Eison (1991) states that "students participate (in active learning) when they are doing something besides passively listening." In a report from the Association for the Study of Higher Education (ASI-IE), authors discuss a variety of methodologies for promoting active learning. They cite literature that indicates students must do more than just listen in order to learn. They must read, write, discuss, and be engaged in solving problems. This process relates to the three learning domains referred to as knowledge, skills and attitudes (KSA). This taxonomy of learning behaviors can be thought of as "the goals of the learning process (Bloom et al, 1956). In particular, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation.

Problem-Based Learning (PBL) is a teaching method in which complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. In addition to course content, PBL can promote the development of critical thinking skills, problem-solving abilities, and communication skills. It can also provide opportunities for working in groups, finding and evaluating research materials, and life-long learning (Duch et al, 2001). PBL can be incorporated into any learning situation. Its uses range from including PBL in lab and design classes, to using it simply to start a single discussion. PBL can also be used to create assessment items. The main thread connecting these various uses is the real-world problem. Any subject area can be adapted to PBL with a little creativity. While the core problems will vary among disciplines, there are some characteristics of good PBL problems that transcend fields (Duch et al, 2001).

The problem must motivate students to seek out a deeper understanding of concepts. The problem should require students to make reasoned decisions and to defend them. The problem should incorporate the content objectives in such a way as to connect it to previous courses/knowledge. If used for a group project, the problem needs a level of complexity to ensure, that the students must work together to solve it. If used for a multistage project, the initial steps of the problem should be open-ended and engaging to draw students into the problem. The problems can come from a variety of sources; newspapers, magazines, journals, books, textbooks, and television/movies. Some are in such form that they can be used with little editing. However, others need to be rewritten to be of use. The following guidelines from "The Power of Problem-Based Learning" (Duch et al, 2001) are written for creating PBL problems for a class centered on the method. However, the general ideas can be applied in simpler uses of PBL: Choose a central idea, concept, or principle that is always taught in a given course, and then think of a typical end-of-chapter problem, assignment, or homework that is usually assigned to students to help them learn that concept and list the learning objectives that students should meet when they work through the problem.

Think of a real-world context for the concept under consideration. Develop a storytelling aspect to an end-of-chapter problem, or research an actual case that can be adapted, adding some motivation for students to solve the problem. More complex problems will challenge students to go beyond simple plug-and-chug to solve it. Look at magazines, newspapers, and articles for ideas on the story line. Some PBL practitioners talk to professionals in the field, searching for ideas of realistic applications of the concept being taught.

The problem needs to be introduced in stages so that students will be able to identify learning issues that will lead them to research the targeted concepts. The following are some questions that may help guide this process: What will the first page (or stage) look like? What open-ended questions can be asked? What learning issues will be identified? How will the problem be structured? How long will the problem be? How many class periods will it take to complete? Will students be given information in subsequent pages (or stages) as they work through the problem? What resources will the students need? What end product will the students produce at the completion of the problem? Write a teacher's guide detailing the instructional plans on using the problem in the course. If the course is a medium- to large-size class, a combination of mini- lectures, whole-class discussions, and small group work with regular reporting may be necessary. The teacher's guide can indicate plans or options for cycling through the pages of the problem interspersing the various modes of learning.

The final step is to identify key resources for students. Students need to learn to identify and utilize learning resources on their own, but it can be helpful if the instructor indicates a few good sources to get them started. Many students will want to limit their research to the internet, so it will be important to guide them toward the library as well. The method for distributing a PBL problem falls under three closely related teaching techniques: case studies, role-plays, and simulations. Case studies are presented to students in written form. Role-plays have students improvise scenes based on character descriptions given. Today, simulations often involve computer-based programs. Regardless of which technique is used, the heart of the method remains the same: the real-world problem.

Conceptual Review

Problem solving being a type of learning is at the pinnacle on Gagne's hierarchy of learning process. It depends on learning of rules and mastery of the lower levels of learning which include; signal learning, stimulus-response learning, chain learning, verbal associate learning, multiple discrimination, learning of concepts and learning of principle (Iyagba, 2020). Problem-Based Learning (PBL) is a recognized teaching method in which complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. With advances in socioeconomic and technical spheres, the individual's life is becoming more complicated, rife with numerous issues that the individual and community will have to deal with in the foreseeable future. It is becoming increasingly necessary for schools to cultivate science attitudes in students so that they can solve challenges individually and adapt better to the future dynamic society. Effective problem solving is one of the key attributes' that separate great leaders from average ones. The role of problem solving necessitates the study of evidence and concepts in order to establish cause-and- effect relationships of environmental physical phenomena (Iyagba, 2020). We have no difficulty carrying out our daily responsibilities because our everyday routines are generally normal. Although this is not always the case; we are often faced with a problem scenario that requires us to consider and come up with a solution in order to achieve our goal. A problem condition arises if there is an impediment to achieving the target. The barrier may be physical, emotional or financial, and it will obstruct the individual's advancement towards the target.

Theoretical Framework

There are two methods from two families of learning theories that are applied to problem solving as mentioned by psychologists. These are (a) cognitive field theory and (b) stimulus-response theory. Cognitive field theory (proposed by Kohler after his research on problem solving mechanism in animals) emphasizes the importance of perceiving the overall situation and the relationship among its components as well as reforming the cognitive field. This theory suggests that a problem is solved all of a sudden after some initial attempt by the participant, based on his research on problem solving. Stimulus-response theorists on the other hand, stress the importance of trial and error. They believe that a dilemma is solved by eliminating mistakes and adding together right solutions over time. These two contrasting methods have witnessed a lot of debate over which method is better suited to problem solving interpretation. Some psychologists believe that the cognitive field theorists approach is best for solving problems that involve more complex thought mechanisms, while the S-R approached is best for solving basic problems (Iyagba, 2020).

A third theory proposed by Harlow in 1959 (after testing monkeys and some humans with poor mental capacities) holds that subjects use trial and error to solve a set of problems at first, but that when identical problems are posed to them in the future, they render accurate discrimination. Harlow believed that the participants got a learning package during the prior trial and error learning (a technique of learning) which they applied to similar dilemma cases in the future making the problems to be solved all of a sudden.

Empirical Review

Problem solving is a systematic search through a range of possible actions in order to reach a predefined goal. It involves two main types of thinking: divergent, in which one tries to generate a diverse assortment of possible alternative solutions to a problem, and convergent, in which one tries to narrow down multiple possibilities to find a single best answer to a problem. Multiple- choice tests, for example, tend to involve convergent thinking, whereas essay tests typically engage divergent thinking.

Many researchers regard the thinking that is done in problem solving as cyclical, in the sense that the output of one set of processes the solution to a problem often serves as the input of another a new problem to be solved. The American psychologist Robert J. Sternberg identified seven steps in problem solving, each of which may be illustrated in the simple example of choosing a:

- Problem identification: In this step, the individual recognizes the existence of a problem to be solved: he recognizes that he is hungry, that it is dinnertime, and hence that he will need to take some sort of action.
- Problem definition: In this step, the individual determines the nature of the problem that confronts him. He may define the problem as that of preparing food, of finding a friend to prepare food, of ordering food to be delivered, or of choosing a restaurant.
- Resource allocation: Having defined the problem as that of choosing a restaurant, the individual determines the kind and extent of resources to devote to the choice. He may consider how much time to spend in choosing a restaurant, whether to seek suggestions from friends, and whether to consult a restaurant guide.
- Problem representation: In this step, the individual mentally organizes the information needed to solve the problem. He may decide that he wants a restaurant that meets certain criteria, such as proximity, reasonable price, a certain cuisine, and good service.
- Strategy construction: Having decided what criteria to use, the individual must now decide how to combine or prioritize them. If his funds are limited, he might decide that reasonable price is a more important criterion than proximity, a certain cuisine, or good service.
- Monitoring: In this step, the individual assesses whether the problem solving is proceeding according to his intentions. If the possible solutions produced by his criteria do not appeal to him, he may decide that the criteria or their relative importance needs to be changed.
- Evaluation: In this step, the individual evaluates whether the problem solving was successful. Having chosen a restaurant, he may decide after eating whether the meal was acceptable.

This example also illustrates how problem solving can be cyclical rather than linear. For example, once one has chosen a restaurant, one must determine how to get there, how much to tip, and so on.

Structures of Problems

Psychologists often distinguish between "well-structured" and "ill-structured" problems. Well-structured problems (also called well-defined problems) have clear solution paths; the problem solver is usually able to specify with relative ease all the steps that must be taken to reach a solution. The difficulty in such cases, if any, has to do with executing the steps. Most mathematics problems, for example, are well-structured, in the sense that determining what needs to be done is easy, though carrying out the computations needed to reach the solution may be difficult. The problem represented by the question, "What is the shortest driving route from New York City to Boston?" is also well-structured, because anyone seeking a solution can consult a map to answer the question with reasonable accuracy. Ill-structured problems (also called ill-defined problems) do not have clear solution paths, and in such cases the problem solver usually cannot specify the steps needed to reach a solution. An example of an ill-structured problem is, "How can lasting peace be achieved between country A and country B?" It is hard to know precisely (or, perhaps, even imprecisely) what steps one would take to solve this problem. Another example is the problem of writing a bestselling novel. No single formula seems to work for everyone. Indeed, if there were such a formula, and if it became widely known, it probably would cease to work (because the efficacy of the formula would be destroyed by its widespread use).

The solution of ill-structured problems often requires insight, which is a distinctive and seemingly sudden understanding of a problem or strategy that contributes toward a solution. Often an insight involves conceptualizing a problem or a strategy in a totally new way. Although insights sometimes seem to arise suddenly, they are usually the necessary result of much prior thought and hard work. Sometimes, when one is attempting to gain an insight but is unsuccessful, the most effective approach is that of "incubation" laying the problem aside for a while and processing it unconsciously. Psychologists have found that unconscious incubation often facilitates solutions to problems.

Discussion

There is no universal law that can be formulated to help students overcome problems. Problem solving is a unique method that necessitates a variety of approaches (Iyagba, 2020). However, there are some indefinite ideas that may prove useful to students in learning the correct mindset to tackle challenges that they may encounter in social situations. These include;

- Moderation motivation: Students are taught how to balance motivation. In order to achieve this, they must avoid excessive/extreme emotional involvement (or low interest) in a problem as they hinder productive thinking.
- Divergent thinking: Students are encouraged to tackle problems in various ways, flexibility and originality are allowed which help develop reasoning when properly guided.
- Level of difficulty: The problems presented should be appropriate for the class considering maturation, motivation and anxiety level. It should be neither too easy nor difficult.
- Practice: students are given various practice problems to help develop proper mental set to solve similar types of problems in future. The rest include active manipulation, whole presentation of problems and incomplete solution (unanswered questions are left for the students for solution as this aids retention).

In all, students are made to develop scientific attitude towards learning via problem solving. In the following examples, students' responses and the teacher's strategies for assisting them demonstrate how learning can be achieved through problem solving.

Scene #1: Connect the dots below using only four straight lines?"

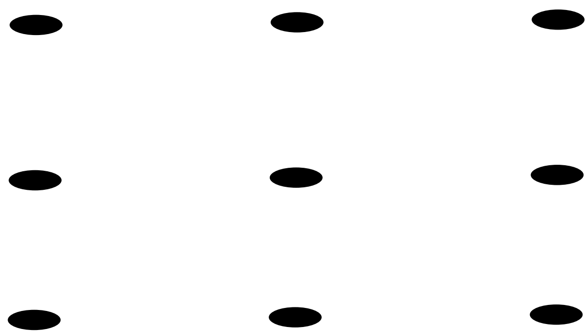

Fig. 1

Nine dots in a three by three grid

The problem itself and the procedure for solving it seemed very clear; simply experiment with different arrangements of four lines. Two volunteers tried doing it at the board, but were unsuccessful. Several others worked at it at their seats, but also without success.

Scene #2: Coaxing students to re-frame the problem.

When no one seemed to be getting it, the teacher asked, "Think about how you've set up the problem in your mind—about what you believe the problem is about. For instance, have you made any assumptions about how long the lines ought to be? Don't stay stuck on one approach if it's not working!"

Scene #3: Alicia abandons a fixed response.

After the teacher said this, Alicia indeed continued to think about how she saw the problem. "The lines need to be no longer than the distance across the square," she said to herself. So she tried several more solutions, but none of them worked either. The teacher walked by Alicia's desk and saw what Alicia was doing. She repeated her earlier comment: "Have you assumed anything about how long the lines ought to be?" Alicia stared at the teacher blankly, but then smiled and said, "Hmm! You didn't actually say that the lines could be no longer than the matrix! Why not make them longer?" So she experimented again using oversized lines and soon discovered a solution:

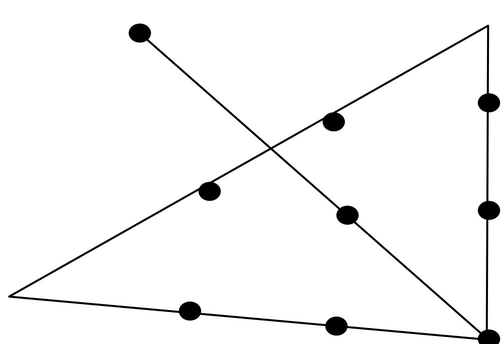

Fig. 2

Nine dots in a three-by-three grid, all dots are connected using just four lines. The first line travels through the top-right dot, the center dot, and the bottom- left dot. The second line travels from the bottom-left dot, through the middle-left dot, and through the top-right dot, then extends past the top-right dot. The third line starts where the second line extended, forming an angle as it passes through the top-middle dot and the middle-right dot. The third line then, extends past the right-middle dot until it is even with the bottom of the grid. The fourth line starts where the third line extended, then passes through the bottom- right, bottom-middle, and bottom-left dots. The end result are four lines, three of which form a right triangle with corners extending beyond the three-by-three grid, with the remaining line bisecting the right angle of the triangle so that it passes through the middle and top-right dots.

Scene #4: Willem's and Rachel's alternative strategies.

Meanwhile, Willem worked on the problem. As it happened, Willem loved puzzles of all kinds, and had ample experience with them. He had not, however, seen this particular problem. "It must be a trick," he said to himself, because he knew from experience that problems posed in this way often were not what they first appeared to be. He mused to himself: "Think outside the box, they always tell you. . ." And that was just the hint he needed: he drew lines outside the box by making them longer than the matrix and soon came up with this solution:

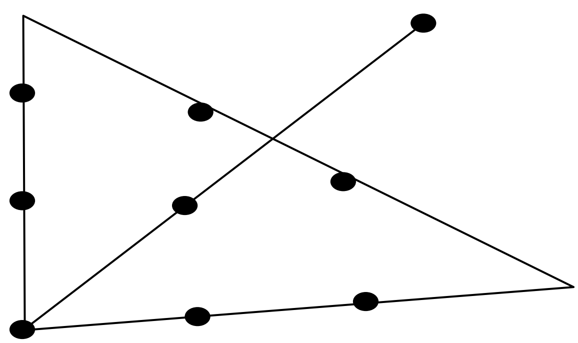

Fig. 3 A mirror image of Alicia's solution

When Rachel went to work, she took one look at the problem and knew the answer immediately: she had seen this problem before, though she could not remember where. She had also seen other drawing-related puzzles, and knew that their solution always depended on making the lines longer, shorter, or differently angled than first expected. After staring at the dots briefly, she drew a solution faster than Alicia or even Willem. Her solution looked exactly like Willem's. This story illustrates two common features of problem solving: the effect of degree of structure or constraint on problem solving, and the effect of mental obstacles to solving problems.

The Effect of Constraints: Well-structured versus Ill-structured Problems

Problems vary in how much information they provide for solving a problem, as well as in how many rules or procedures are needed for a solution. A well-structured problem provides much of the information needed and can in principle be solved using relatively few clearly understood rules. Classic examples are the word problems often taught in math lessons or classes: everything you need to know is contained within the stated problem and the solution procedures are relatively clear and precise. An ill-structured problem has the converse qualities: the information is not necessarily within the problem, solution procedures are potentially quite numerous, and multiple solutions are likely (Voss, 2006). Extreme examples are problems like "How can the world achieve lasting peace?" or "How can teachers insure that students learn?"

By these definitions, the nine-dot problem is relatively well-structured though not completely. Most of the information needed for a solution is provided in Scene #1: there are nine dots shown and instructions given to draw four lines. But not all necessary information was given: students needed to consider lines that were longer than implied in the original statement of the problem. Students had to "think outside the box," as Willem said in this case, literally.

When a problem is well-structured, so are its solution procedures likely to be as well. A well-defined procedure for solving a particular kind of problem is often called an algorithm; examples are the procedures for multiplying or dividing two numbers or the instructions for using a computer (Leiserson, et al., 2001). Algorithms are only effective when a problem is very well-structured and there is no question about whether the algorithm is an appropriate choice for the problem. In that situation it pretty much guarantees a correct solution. They do not work well, however, with ill-structured problems, where they are ambiguities and questions about how to proceed or even about precisely what the problem is about. In those cases it is more effective to use heuristics, which are general strategies "rules of thumb," so to speak that doesn't always work, but often do, or that provide at least partial solutions. When beginning research for a term paper, for example, a useful heuristic is to scan the library catalogue for titles that look relevant. There is no guarantee that this strategy will yield the books most needed for the paper, but the strategy works enough of the time to make it worth trying.

In the nine-dot problem, most students began in Scene #1 with a simple algorithm that can be stated like this: "Draw one line, then draw another, and another, and another." Unfortunately this simple procedure did not produce a solution, so they had to find other strategies for a solution. Three alternatives are described in Scenes #3 (for Alicia) and 4 (for Willem and Rachel). Of these, Willem's response resembled a heuristic the most: he knew from experience that a good general strategy that often worked for such problems was to suspect a deception or trick in how the problem was originally stated. So he set out to question what the teacher had meant by the word line, and came up with an acceptable solution as a result.

Common Obstacles to Solving Problems

The example also illustrates two common problems that sometimes happen during problem solving. One of these is functional fixedness: a tendency to, regard the functions of objects and ideas as fixed (German & Barrett, 2005). Over time, we get so used to one particular purpose for an object that we overlook other uses. We may think of a dictionary, for example, as necessarily something to verify spellings and definitions, but it also can function as a gift, a doorstop, or a footstool. For students working on the nine-dot matrix described in the last section, the notion of "drawing" a line was also initially fixed; they assumed it to be connecting dots but not extending lines beyond the dots. Functional fixedness sometimes is also called response set, the tendency for a person to frame or think about each problem in a series in the same way as the previous problem, even when doing so is not appropriate to later problems. In the example of the nine-dot matrix described above, students often tried one solution after another, but each solution was constrained by a set response not to extend any line beyond the matrix.

Functional fixedness and the response set are obstacles in problem representation, the way that a person understands and organizes information provided in a problem. If information is misunderstood or used inappropriately, then mistakes are likely if indeed the problem can be solved at all. With the nine-dot matrix problem, for example, construing the instruction to draw four lines as meaning “draw four lines entirely within the matrix” means that the problem simply could not be solved. For another, consider this problem: “The number of water lilies on a lake doubles each day. Each water lily covers exactly one square foot. If it takes 100 days for the lilies to cover the lake exactly, how many days does it take for the lilies to cover exactly half of the lake?” If you think that the size of the lilies affects the solution to this problem, you have not represented the problem correctly. Information about lily size is not relevant to the solution, and only serves to distract from the truly crucial information, the fact that the lilies double their coverage each day. (The answer, incidentally, is that the lake is half covered in 99 days; can you think why?)

Strategies to Assist Problem Solving

Just as there are cognitive obstacles to problem solving, there are also general strategies that help the process be successful, regardless of the specific content of a problem (Thagard, 2005). One helpful strategy is problem analysis— identifying the parts of the problem and working on each part separately. Analysis is especially useful when a problem is ill-structured. Consider this problem, for example: “Devise a plan to improve bicycle transportation in the city.” Solving this problem is easier if you identify its parts or component sub problems, such as (1) installing bicycle lanes on busy streets, (2) educating cyclists and motorists to ride safely, (3) fixing potholes on streets used by cyclists, and (4) revising traffic laws that interfere with cycling. Each separate sub-problem is more manageable than the original, general problem. The solution of each sub-problem contributes the solution of the whole, though of course is not equivalent to a whole solution.

Another helpful strategy is working backward from a final solution to the originally stated problem. This approach is especially helpful when a problem is well-structured but also has elements that are distracting or misleading when approached in a forward, normal direction. The water lily problem described above is a good example: starting with the day when all the lake is covered (Day 100), ask what day would it therefore be half covered (by the terms of the problem, it would have to be the day before, or Day 99). Working backward in this case encourages reframing the extra information in the problem (i. e. the size of each water lily) as merely distracting, not as crucial to a solution. A third helpful strategy is analogical thinking using knowledge or experiences with similar features or structures to help solve the problem at hand (Bassok, 2003). In devising a plan to improve bicycling in the city, for example, an analogy of cars with bicycles is helpful in thinking of solutions: improving conditions for both vehicles requires many of the same measures (improving the, roadways, educating drivers). Even solving simpler, more basic problems is helped by considering analogies. A first grade student can partially decode unfamiliar printed words by analogy to words he or she has learned already. If the child cannot yet read the word screen, for example, he can note that part of this word looks similar to words he may already know, such as seen or green, and from this observation derive a clue about how to read the word screen. Teachers can assist this process, as you might expect, by suggesting reasonable, helpful analogies for students to consider.

Conclusion

It is important to pay attention to the learning process and its various dimensions in one's work as a teacher. Understanding students as learners with their unique goals, motivations, beliefs and learning practices will help one be a better teacher. The foundation of good teaching is attention to student learning.

References

Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C., and Norman, M.K. (2010). *How learning works: Seven research-based principles for smart teaching*.

Bassok, J. (2003). Analogical transfer in problem solving: In Davidson, J. & Sternberg, R. (Eds.): *The psychology of problem solving.*

Bloom, B. S., Krathwohl, D. R., and Masia, B. B. *(1956). Taxonomy of educational objectives: The classification of educational goals*. David McKay Company.

Bonwell, C. C., and Eison, J. A. (1991). Active Learning: Creating Excitement in the Classroom. *ASHE-ERIC Higher Education Reports*.

Britannica (2020). The Editors of Encyclopaedia: "Learning". Encyclopedia Britannica, 10 Nov. 2020, https://www.britannica.com/science/learning. Accessed 17 May 2021.

Duch, B. J., Groh, S. E, and Allen, D. E. (Edsj. (2001). *The power of problem- based learning.* Stylus. ERIC Clearinghouse on Higher Education, The George Washington University, DC 20036-1183.

German, T., and Barrett, H. (2005). Functional fixedness in a technologically sparse culture. *Psychological Science*, 16(1), 1—5.

Iyagba, P. W. (2020). *Advanced Educational Psychology, Learning and Developmental Dynamics*. Port Harcourt: Akanso Authentic Tech (AKATECH).

Leiserson, C., Rivest, R., Cormen, T., and Stein, C. (2001). *Introduction to algorithms*. MIT Press.

Luchins, A. and Luchins, E. (1994). The water-jar experiment and Einstellung effects. Gestalt Theory. *An International Interdisciplinary Journal*, 16(2)101-12 1.

Mayer, R. & Wittrock, M. (2006). Problem-solving transfer. In D. Berliner & R. Calfee (Eds.), *Handbook of Educational Psychology*, pp. 47—62. Erlbaum.

Renki, Alexander; Atkinson, Robert K.; Maier, Uwe H.; Staley and Richard (2002). "From Example Study to Problem Solving: Smooth Transitions Help Learning". *The Journal of Experimental Education,* 70 (4): 293-315.

Renkl, A. A., Robert K. M., Uwe H. & Staley R. (2002). From Example Study to Problem Solving: Smooth Transitions Help Learning. *The Journal of Experimental Education,* 70 (4): 293-315.

Svinicki, M. D. (1999). New directions in learning and motivation. In M. Svinicki (Ed.), *New Directions for Teaching and Learning,* 80, 5-27.

Thagard, R. (2005). *Mind: Introduction to Cognitive Science*, 2nd edition. Cambridge, MA: MIT Press.

Voss, J. (2006). Toulmin's model and the solving of ill-structured problems. *Argumentation*, 19(3), 321-329.