Problem solving: A psycho-pragmatic approach
Paul Giannakopoulos, BSc, HEd, BEd, MEd
Faculty of Engineering, University of Johannesburg
Johannesburg, South Africa
paulg@uj.ac.za
Sheryl B. Buckley, BEd, MEd, D Litt Et Phil
Faculty of Business Management, University of Johannesburg,
Johannesburg, South Africa
sherbuck@gmail.com

Abstract
The aim of this paper is to present an alternative approach to problem solving in general and mathematics in particular. Problem solving has become very prominent especially in the last two decades due to a number of reasons: the move from an industrial society to a knowledge society; globalisation; complexity in management systems; and technological innovations, to name just a few (Halpern, 1997; Pascarella & Terenzini, 1991; Bérubé & Nelson, 1995). An analysis of the various definitions and research indicates that problem solving: involves a number of cognitive processes (e.g. analysis, synthesis, comprehension and so on); it requires a certain mode of thinking for different problematic situations; and it is a skill that needs to be developed over a period of time (Green & Gillhooly, 2005:347; Halpern, 1997:219).

Behaviourism and cognitivism learning theories have been used in the teaching and learning situation but with mixed results. Pragmatism on the other hand has started “re-emerging” due to a number of reasons. The most important reason that was “rejected”: Emphasis on the practical application of knowledge. Mathematics, unlike other subjects, by its nature is a subject whereby problem solving forms its essence but paradoxically is “accused” of being too abstract. However, there can be no mathematics without problem solving. A generic model is developed where by the psychological theories as well as pragmatism are used in the teaching and learning situation.

Introduction
As the world economy moved from an industrial economy to a knowledge economy, it can be argued that the nature of many problems also changed and new problems have arisen which may require a different approach to overcome them. Certain problems remained unchanged for the human being. For example, human beings that are born, they have to learn how to walk, run, speak and so on. Educational institutions and governments have recognised long ago the importance of problem solving and volumes of research have been written about problem solving (Pushkin, 2007; Astin, 1993; Halpern, 1997; Pascarella & Terenzini, 1991; National Education Goals Panel, 1991; South African Qualifications Authority (SAQA), 1998; National Council of Teachers of Mathematics [NCTM], 2005). Universities and other higher learning institutions are entrusted with the task of producing graduates that have such higher order thinking skills among other skills (Pushkin, 2007; Astin, 1993).

Theories about learning in general and problem solving in particular have also taken cognizance of these changes and old theories have been revisited and modified if necessary while new ones have come to existence. Behaviourism, cognitivism and their variations dominated and still dominate education where depending on the style of the teacher he or she uses more than one and less of the other. Since learning is about knowledge, the difference between the two theories lies on the fact that the one views learning as acquisition of knowledge while the other as knowledge construction. Both theories recognise that problem solving is essential for all learners (Johansen, 2003) especially complex problems (DeCorte,
However, the ‘how’ to teach and ‘what to teach’ to achieve this is still debatable. Pragmatism on the other hand has started ‘re-emerging’ due to a number of reasons. The most important one being the main reason that was “rejected”: Emphasis on the practical application of knowledge. Mathematics, unlike other subjects, by its nature is a subject whereby problem solving forms its essence but paradoxically is “accused” of being too abstract. However, there can be no mathematics without problem solving. There is evidence (Luneta, 2008; Pushkin, 2007; Williams, 2005) that success in mathematics is directly related to academic success as mathematics is contained in other subjects to a greater (e.g. physics, strength of materials, thermodynamics and so on) or a lesser extent (e.g. history, geography, psychology and so on). A generic model is developed where by the psychological theories as well as pragmatism are used in the teaching and learning situation to improve problem solving and academic success.

Learning theories

For the last twenty years behaviourism, cognitivism and variations of them have shed some light to the phenomenon of learning in general and in mathematics in particular. Hergenhahn & Olson (1997) discuss the various learning theories in detail. Briefly, according to behaviourism learning brings change in behaviour as we learn through experiencing the world. By responding to the environment we learn (stimulus-response phenomenon). However, there are internal processes that are involved in learning. It is cognitive psychology that is concerned with these various mental activities (such as perception, thinking, knowledge representations and memory) related to human information processing and problem solving (Shuell, 1986 cited in Hergenhahn & Olson, 1997).

Cognitive psychology like behavioural psychology has given rise to a number of different perspectives such as constructivism and variations of it such as, personal (Kelly (1955) and Piaget (1972), radical (Von Glasersfeld, 1985, 1987a, 2002), social (Vygotsky (1978), critical (Taylor) and contextual (Cobern) (all cited in Venter, 2003). Parsons, Hinson & Sardo-Brown, (2001:431) define constructivism as a “cognitive theory emphasising learner interest in and accountability for their own learning which manifests in student self-questioning and discovery.” In a way it was a reaction to the traditional way of teaching that gave rise to it. Constructivism is a theory of how learning occurs (Henson, 1996 cited by Parsons et al., 2001) rather than the product of such learning. This learning theory is student-centred where learners are actively involved in constructing their own knowledge and making use of past experience or prior learning or pre-existing schemas.

However, John Dewey saw existing theories to be too theoretical and lacked practicality, applicability, usefulness. So pragmatism was born. It endorses practical theory (theory that informs effective practice; praxis). And according to pragmatism knowledge is validated by its usefulness: ‘What can we do with it!’ Of late pragmatism (Johnson & Onwuegbuzie, 2004; Schaffler, 1999) has started gaining ground again as it is felt by some educationists we have become too theoretical again. The pragmatic view stresses the experimental character of the empirical science, emphasising the active phases of the experimentation. It promotes an inquiring mind with respect to physical laws. “Inquiry itself is action, but action regulated by logic, sparked by theory, and issuing answers to motivating problems of practice” states (Scheffler, 1999:4). For pragmatism knowledge is viewed as being both constructed and based on the reality of the world we experience and live in. Learning from experiences is an active process. The mind is viewed as a capacity for active generation of ideas whose function is to resolve the problems imposed to the organism (the human being) by the environment. Pragmatism encourages imaginative
theorising by the student but at the same time insists upon control of such theorizing by the outcomes of active experimentation (Scheffler, 1999).

**The psycho-pragmatic approach to teaching and learning in problem solving**

This approach combines behaviourism and cognitivism (neocognitivism, the psychological aspect) and pragmatism. Pragmatism could be seen as the missing link between the other two theories as it promotes learning from experiences which is an active process. For this reason, this new paradigm gets its name “Act of learning” (see Figure 1), which gives rise to ‘thinking while doing’ and ‘doing while thinking’. Thus the constructs ‘thinking’ and ‘doing’ form the two pillars of the learning. So the first step in the teaching – learning situation is the promotion of these two actions. But thinking can be of low (concrete) or high (abstract) order. Through thinking and doing, concepts are formed in a conscious as well as subconscious way. But concepts can be primary or secondary. Primary concepts give rise also to other secondary concepts. Concepts can be concrete or abstract and as concepts are connected and form a web of connections, principles are formed. This is the second step in teaching – learning situation, concept formation, a very important prerequisite to problem solving. Various principles make up the structures of knowledge as knowledge is either acquired and assimilated in the existing cognitive structure or knowledge is constructed and a re-structuring of the cognitive structure takes place. Experience adds a new dimension to existing knowledge as a result tacit knowledge also becomes part of the cognitive structure. Knowledge can be of different types such as procedural (knowing how), declarative or conceptual (knowing ‘that’), schematic (knowing ‘why’), and strategic (knowing ‘where, when and how’) (Hiebert & Lefevre, 1986; Shavelson, Ruiz-Primo & Wiley, 2005; Stolovitch & Keeps, 2002).

It can be said knowledge remains dormant in the cognitive structure and it comes to life when a problem is encountered, when the knowledge has to be applied into a real situation, the pragmatic aspect. If a problem is defined as an ‘obstacle’ on the path of an individual to a goal, then problem solving is finding a way out of a difficulty, a way around an obstacle, attaining an aim that was not immediately understandable (Polya, 1973). Green and Gilhooly (2005:347) state that ‘problem solving in all its manifestations is an activity that structures everyday life in a meaningful way.’

Knowledge can be viewed as a ‘tool’ used to solve problems. But possessing any tool (be it a drill, a spade, a welding machine and so on) is not sufficient. One has to have the skill to use it. A skill is defined as expertise developed in the course of training and development (Malone, 2003). “A skill is an ability to do something well, to competently perform certain tasks” and “they (skills) consist, in part, of methods and strategies that have been incorporated into a performance routine” (Smith, 2002). Ferrett (2008:467) associates skills with capabilities that have been learned and developed. Skills include trade or craft skills, professional skills, social and sporting skills or more broadly motor skills and cognitive skills. And one of the most important cognitive skills is use of critical thinking (see Figure 1) which precedes problem solving. This is the third step in the teaching – learning situation. A literature review though on critical thinking and problem solving revealed that there is no conclusive evidence that critical thinking is a prerequisite to problem solving or vice versa (Papastephanou & Angeli, 2007). From a mathematics perspective, irrespective of the type of problem to be solved, in every step of the solution, given information needs to be critically examined. The pragmatic approach then to problem solving creates a new approach to problem solving (see Figure 2).

Problem solving then is an outcome of a number of co-ordinated cognitive processes. Existing knowledge combined with critical thinking skills are applied to a real problematic situation. Irrespective of the problem solving method to be used, from the simplistic Polya’s approach (understanding the
problem, devising of a plan, carrying out the plan, looking back (evaluating)) to a more comprehensive model of Sternberg (2007) (see Figure 3) every step requires a certain type of knowledge and information to be critically examined.

Figure 1 *The act of learning*
However, the success of implementing such teaching-learning approach depends on the two main role players, the teacher and the learner. Briefly speaking, the teacher has to become what Solomon and Morocco (1999) call a diagnostic teacher. Diagnosing goes beyond finding out what the learners know. It is about understanding students’ “particular thinking patterns, current understandings, or misconceptions” (Solomon & Morocco, 1999:234). A teacher who concentrates on diagnosing focuses on the individual rather than the class. Diagnosing is non judgemental. It concentrates on trying to understand student’s understanding and “assessment is part of a recursive cycle of observation, selection of teaching strategies, reflection, and readjustment of one’s strategies” (Solomon & Morocco, 1999:34). The learner, has to be willing to learn and if necessary to restructure his or her cognitive structure (Vosniadou, 1999). Furthermore the teacher has to become a researcher. Structural equation modelling (SEM) (as discussed in detail by Ullman and Bentler (2004) can be of great help when he or she evaluates their teaching.

Finally, the ‘Act of learning’ is of cyclic as well as of a spiral nature. Cyclic, by the virtue that the learning of concepts and problem solving go through the various steps; spiral, due to the fact that concepts are acquired in higher levels in each cycle.

**Conclusion**

The above exposition introduced a new approach to problem solving, which can be applied in any situation, any subject. This approach complements the behaviourist and the cognitivist approach to learning by combining them with pragmatism. Pragmatism brings problem solving to life by applying knowledge to real situations. However, the success of it depends mainly on the teacher becoming a diagnostic teacher.

**Bibliography**


