SUMMARY

This study explored the cognitive mechanisms of problem solving in physics and their relationships to the students' problem-solving strategies. Before the study was designed and commenced, a pilot study and thorough review of literature was conducted. Based on the critical review of prior research and on the author's own extensive teaching experience, a new "BARK" theory[1] of describing the problem-solving skills was proposed.

This theory suggests the existence of a meaningful dichotomy between the students' *rigid knowledge* (defined as the set of previously learned "standard" facts and procedures) and their *bisociation* skill (defined as the ability to relate one's rigid knowledge to a new, unfamiliar problem situation). The author proposes that rigid knowledge and bisociation are, indeed, distinct "mental assets" at the student's disposal, and that for many students it is the lack of bisociation that limits the ability to solve physics problems.

The goals of the study were to test the proposed theory and to gain further insight into the nature of difficulties facing problem solvers and the *general* strategies that help successful solvers to overcome those difficulties. My hope was to find the evidence supporting the theory and, using the findings, to formulate the teaching strategies that would improve the students' bisociation skills and, consequently, their problem-solving ability.

To conduct the study, a large group of AP Physics C students was given several physics tasks to solve. The participants' interactions with the tasks were then observed and recorded in several different ways. The data collected were then analyzed in conjunction with the background information provided by the students. The highlights of my design include:

- offering the students quite challenging tasks to solve;
- designing tests probing rigid knowledge and bisociation separately;
- using a large national sample of AP Physics C students;
- delivering the tasks over the Internet;
- using an innovative Internet platform, CyberTutor, to deliver the tasks;
- collecting the data both from CyberTutor tasks and the student interviews;
- combining statistical and qualitative methods of data analysis.

While any one of these features can, indeed, be found in existing research, I believe that it is their combination that made my study unique and my findings non-trivial and useful.

To analyze the CyberTutor data, various statistical methods were used. In particular, correlation statistics and linear regression models were used to determine the factors relevant to individuals' success in problem solving. The written comments made by the students and the protocols of student interviews were analyzed qualitatively, using the narrative summary and the cluster methods.

My research results do support the idea of rigid knowledge and bisociation being two distinct sets of skills essential to problem solving; the notion of bisociation as the main factor limiting one's problem-solving success was also supported. It was also found that the factors significant in predicting one's success in problem solving appear to be different for male and female students. In addition, I was able to observe and record the specific behaviors associated with both successful and unsuccessful problem-solving processes. Based on my findings, I proposed several instructional approaches that may be used to help the students enhance their problem-solving skills, in a physics classroom and beyond.

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[1] After having been to several national AAPT Meetings, I realized that no research can gain acceptance unless it is epitomized by a catchy acronym. I credit myself with at least *conducting the study first* and only *then* trying to come up with a suitable acronym (many of my colleagues in the field appear to be doing things the other way around). BARK stands for "Bisociation And Rigid Knowledge." Maybe, I am barking up the wrong tree here…

In general, I consider the study a success, for these reasons:

- I managed to follow the scope and the original design of the study despite some logistical difficulties; many features of my design may, I believe, become "standard" in future problem-solving studies;
- The proposed theory was well supported by the evidence; moreover, the theory appears to be directly useful in designing further research studies, curriculum materials and instruction strategies;
- The study has helped me formulate new research questions that may well become a foundation of a promising line of research.