AN INTEGRAL FRAMEWORK OF CONSTRUCTIVIST INQUIRY TEACHING, ACTION LEARNING AND DEVELOPMENTAL ASSESSMENT IN TEACHING OF SCIENCE

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This framework-embedded paper is meant for science teachers and institutions searching for alternatives. The illustrative framework is an outcome of research experience in working with in-service and pre-service teachers in India and the Pacific. Drawn from research trends and pedagogic practices, the authors present an integrated view of using appropriate pedagogical designs, action-learning cycles and assessment procedures. The idea of integrating constructivist teaching and action-learning with adopted Developmental Assessment procedures, came from an Australian source (ACER's assessment resource kit), Vygotsky's ZPD (McInerney & McInerney,1998), and Rasch model on Task Difficulty Range (Masters, 1996). The paper unfolds a number of accepted constructivist assumptions, meanings, pedagogic designs and learning environments. Illustrating the framework details, the paper concludes with impeding realities in its implementation.

WHAT WE KNOW ABOUT

Worldviews about scientific knowledge as participatory human interpretations and scientific investigations as construction of human explanations (Brew, 1999) have been duly acknowledged in the impacting scenario of Globalization and its aftermath, Internationalization of education. Viewed from an epistemological perspective, a variety of constructivist methodologies with responsive foci have emerged as a spectrum of alternatives to the prevailing objectivism (Guba & Lincoln, 1989). There is enough research evidence and literature in personal and social constructivism in favour of equipping teachers and students with metacognitive strategies of learning how to teach and learning how to learn tools (Fraser & Walberg, 1995).

Encompassing vivid explanations of constructivism, there are a number of established pedagogical approaches with compatible learning environments. One can cite a number of examples to illustrate this view. 1. Constructivism is one way of making sense; a theory of knowledge that explains how we know about what we know; as a pedagogical referent, the way of what and how teachers perceive, reflect, teach and learn. Students in constructivism learn from their interactive experiences with events, objects or phenomena. From this perspective, science teaching or learning is not only a search for objectified truths, but a construction process of relative truths that make up for multiple meanings (Lorsbach & Tobin, 1997). 2. Constructivism is a notion about how people build their own knowledge and represent knowledge from their own experiences. This notion is grounded in the Piagetian theory of cognitive learning, interactual and cultural emphases of Vygotsky, and John Dewey's educational progressivism (Ramos, 1999).

The Early Childhood program in Tuskegee University (Alabama) is a better convergence of Piaget's constructivism and Dewey's progressivism. The program is structured to promote preservice teachers with experiential reflective practice in inclusion of autonomous, inquisitive thinking learners. The philosophical assumptions that this program enunciates include: (a) learning as a process of knowledge construction with a means of reflection tools – dialogue, active participation and practicing – a source of experience; (b) three interrelated elements of development-oriented reflective teaching: focused observation, creation of learning environments that trigger students' development and interests toward experimental practice, and a prime emphasis laid on the aesthetic aspects of teaching; and (c) feedback-based student-internalizing evidences for problem-solving, reflection and questioning (Noori, 1994). Having considered the above constructivist guidelines and correct ideas, a renewed search for more directed instructional and learning details was undertaken in line with the adopted developmental assessment procedures.

HOW WE KNOW ABOUT WHAT WE KNOW

A wide range of research studies have focused on inquiry-based instructional designs, action-learning and problem-based learning cycles. Dwight D. Eisenhower Mathematics and Science Education (Indiana), sought to enhance learning in science by improving teaching of science in grades K – 8. Using interdisciplinary science teaching during summer workshops, the project involved science teachers in developing activity-based science instructional material through cooperative participatory exercises. Teachers developed materials for science concept enrichment, process skills development, pre- and post evaluative instruments, and relevant computer applications. These materials were implemented in their teaching during the academic year and submitted for review along with a host of student work samples, such as journals, record sheets, reports, concept maps, art projects, and so on. The results underscore teacher-prepared multiple assessments for realistic teaching-learning process in science (Jones, Dorothy & Others, 1996).

Freedman (1998) conducted a study to describe assessment environment in constructivist-oriented science, technology, and society (STS) classrooms. Implying inclusion of constructivist assessment practices for science courses, the study drew on the ideas of using active learning, prior knowledge, and learner responsibility. Working on with a constructivist approach in scientific investigations, Birse (1996) focused on specific inquiry strategies such as observation, designing, questioning, prediction, discussion and recording experiences to demonstrate successfully for non-specialist science teachers. Hankes (1996) presenting a paper on constructivist based instruction at the annual convention of the American Educational Research Association, concluded that constructivist pedagogic principles: of teacher as facilitator, of learner centred foci, of culturally located experiential problem-based and cooperative instruction, could only be practiced in culturally sensitive and responsive environments. Carr (1997) reported that a restructured science course on constructivist lines: lecture- free, problem-centred, and collaborative reflective-judgment pedagogic framework – resulted in fostering the development of diversified reflective judgment capacity in science students. Similar to Carr's (1997) study, Chang (1998) conducted a study course based on social constructivism for in-service science and mathematics teachers. The study details included letting the teachers construct their own teaching knowledge by cooperative problem-solving, sharing information and ideas, writing journals and reports, and investigating their own teaching problems. Colburn (1998), addressing basic ideas of constructivism in the context of science, recommended using open-ended hands-on activities, cooperative learning and questioning strategies including student journals in curriculum based learning cycles.

WHAT RESEARCH IMPLIED

The above reviewed research was helpful in finding answers related to how teachers construct instruction, how students learn science, how the nature of science determines the nature of teaching-learning process, how constructivist principles could be processed into classroom dynamics, how learning environments and styles could be created and integrated, and how assessment measures be incorporated into the instruction of science. However, certain constructivist principles were noticed in Stein and Others (1994) study, that raised framework related concerns; such as:

> Constructivist teaching involves meeting students "where they are" and helping them move to higher levels of knowledge and understanding; the constructivist teacher uses continuous assessment to facilitate learning; and constructivist teachers are themselves constructivist learners.

These principles on locating or relocating student levels of learning attainments individually and collectively; and, using continuous assessment with its original emphasis for assisting and monitoring progress in learning, especially in the light of differential student attainment levels, were felt both crucial and critical concerns to the framework formulation. They raised the issues of incorporating instructional and assessment strategies into metacognitive learning process.

HOW THE ISSUE WAS RESOLVED

Holton and Clarke (2006) proposed expanded conception of scaffolding with four key elements:

> (1) Scaffolding agency—expert, reciprocal, and self-scaffolding; (2) scaffolding domain —conceptual and heuristic scaffolding; (3) the identification of self-scaffolding with metacognition; and (4) the identification of six zones of scaffolding activity…

Abstract of this journal article offered a major breakthrough in resolving the concerns raised above. Especially, the last two key elements: each zone of the listed distinguished the learning matter under construction and the relative positioning of the learner(s) in the act of scaffolding. Science teachers can be visualized situating metacognition within a framework derived from the social activity of scaffolding – a bridge could be found between the instructional support and the learner's self-control of the learning process. The best way of illustrating differential student attainment levels of learners and scaffolding would be by picturing Vygotsky's definition of zone of proximal development (as cited in McInerney & McInerney, 1998, 39).

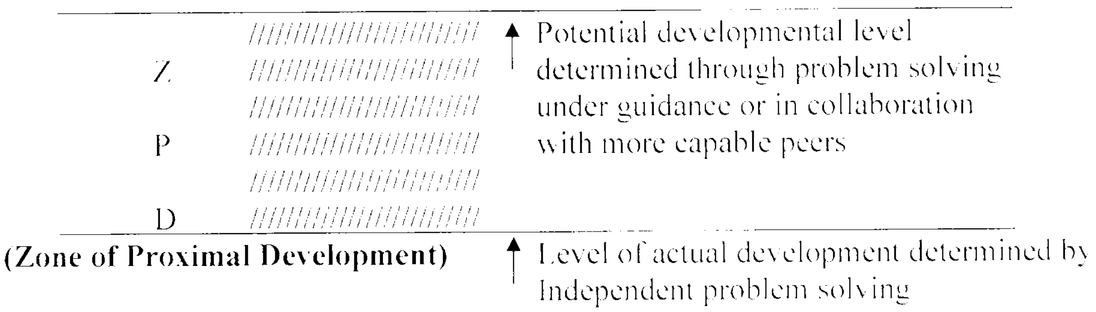
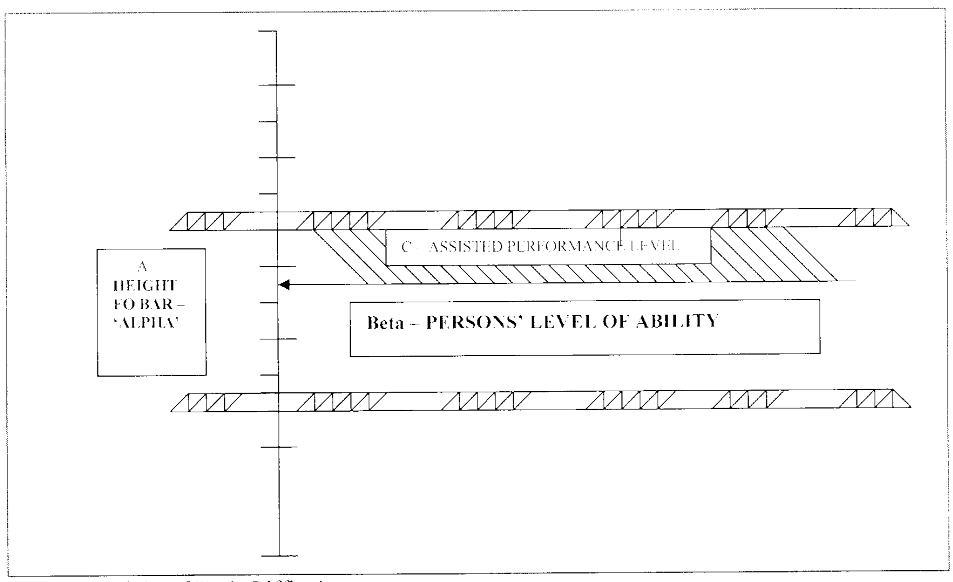


Figure 1: Pictorial View of Vygotsky's Zone of Proximal Development

The above picture clearly indicates the zone between actual level of performance and potential level of performance that could be addressed with scaffold assistance. This is the region where proposed integral framework addressed the issue. However, developmentally, the zone of proximal development seems to be a more generalized concept applicable in a group situation. Rasch model of task difficulty range offered a useful solution that assisted to tie-up individual situations with developmental learning. The following sketch is an adapted form of this model from Masters (1996).



Alpha = Height of Task Difficulty
Beta = Person's level of ability

Figure 2: Adapted Scale of Rasch's Increasing Task Difficulty Range Showing Person's Actual Level and Potential Level of Ability - Beta

The above picture shows how a learner's *probability of success* decreases with increase in task difficulty. *"The more difficult the task (i.e., the higher the bar), lower* would be the person's modelled *probability of success"* (Masters, 1996, 18). Improving and monitoring learning between the actual and potential ability could be supported with the help of (area 'C') scaffold assistance through instruction, action-learning and developmental assessment. Having settled the metacognition issues of the framework the tasks of selecting and adopting appropriate constructivist teaching, learning and assessment became very clear.

PUTTING IT ALL TOGETHER

The reviewed researches had focused on Inquiry-based, problem-based, action-learning teaching and learning designs. Focusing more or less on these designs, there are a good number of academic texts offering practical guidelines to science teachers at all levels of school learning. Teaching of Elementary Science: A Full-Spectrum Science Instruction Approach, by Esler and Esler (2001) is one of such books. Chapter 3: Teaching Science by Constructivist Inquiry Methods, of this source with its instruction processes of teaching science were found relevant for the framework.

In line with the action-learning, problem-solving and cooperative learning methods (Hankes, 1996; Carr, 1997; Chang, 1998; & Colburn, 1998), Reg Raven's Action Learning model, as documented has been incorporated into the framework (Introduction to Action Learning, n. d.). According to this model, learning is determined by:

> The individuals' ability / willingness to question (Q) his / her programmed knowledge (P) using the stimulus of real life problems, having a) the support of others who are also working to support themselves, b) the challenge provided by the facilitator and c) the will to reflect and learn from the action.

Table: Key Components of the Integral Framework

Inquiry Science Instruction (Process – Process Science)	**Action Learning Cycle** (Cooperative & Collaborative)	Developmental Assessment (Procedures)
1. Problem-solving through rational inquiry approach 2. Effective Questioning 3. Discovery Learning 4. Scaffold Experimentation 5. Field-Linking Activities 6. Using integrated spectrum of science process skills	1. Work with a real life problem 2. Encourage to question 3. Trial-out suggested solutions 4. Stay-put and reflect on what happened 5. Share experience by communication	1. Using progress maps for learning attainments 2. Using a range of appropriate assessment methods & collecting information 3. Judging and recording student performance and work 4. Making on-balance estimates of students'

		attainment levels 5. Reporting student accomplishments and progress in comparison with the progress and framework

The Australian Council for Educational Research (ACER) brought out *Assessment Resource Kit (ARK)* material in 1996, comprising of eight (8) booklets in addition to a workshop manual for the professional development of teachers. According to the authors of this material (Masters & Forster, 1996),

> Developmental assessment is considered as a continued monitoring process of students' progress and feeding forward for improvement in an area of learning in reference to their biological and intellectual developmental stages…In the development assessment student progress is monitored at regular intervals and progressive or retrograde changes are estimated and provided teacher support (pp.1-8).

This description of development in assessment process self explains for its significance in the ongoing discussion on constructivist science instruction and action learning process. Moreover, one of the authors of this paper tried out the *framework* by offering a summer course in Cook Islands in January 2005, on a group of 16 student teachers. The key elements of the course included: material supported lecture–free sessions, involvement of students in the development of journals, students' written seminars, student work samples, and open tests.

WHAT IMPEDIMENTS WE FORE SEE

With managerial and infrastructural support and made available academic freedom for the teachers, the above framework for science instruction might work successfully in autonomous school districts. However, a range of social realities, such as listed here, could be common in the developing countries: (1). A combination of mandated state school curricula that exist in a state may have inadequate equipment, and or lacked teacher experience. (2) In realistic social environments, teachers might hold the responsibility of facilitating students' learning, but may not be willing to take responsibility for progress in their learning. Applying instructional assessment strategies in active learning environments could become problematic in such contexts. (3) As Dharmadasa (2000) reported in her study, teachers in realistic situations may view constructivist approach to teaching as a challenge, an additional burden, and a disrupting source for classroom discipline. (5) The proposed framework may be effectively applicable in small group settings; where, teacher-student ratios exceed 1:20, implementing this framework needs reconsideration.

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