Designing for Children
- With focus on 'Play + Learn'

Developing Mathematical Concepts for E- learning by Engaging Multiple Intelligences: a proposal for a new framework –CRIB

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Abstract: If there is one subject that should be taught on an individual basis, it is mathematics. But most school children do not receive individualized instruction. The majority of math classes consist of a teacher-led lesson directed at the whole class followed by individual practice and sometimes group-activity reinforcement. New teaching methods that have come up do allow students to work through a text book at their own pace, using the teacher as a resource when necessary. This works well for students who are strong conceptual learners and can process information through written instructions. But a student who learns better through hands-on experiences will flounder through this type of textbook only learning. Traditional styles of teaching focus almost exclusively on auditory presentation of material to students — in other words, lecturing. With the coming up of varied educational technology, it's the right time to move away from that traditional model towards methods of teaching that address children's multiple intelligences and are appropriate to different types of learners, not only auditory learners.

Through the premises of this study an E-Learning package called Math For Everyone was developed, including a newly conceived application tool known as CRIB (Concept Reinforcement Idea Board)-a tool to represent a concept in different ways by engaging multiple modalities, to reinforce the idea catering to the varied learning styles. CRIB has been developed keeping in mind the results shown by brain research (how human memory works), learning theories such as MI (multiple intelligence) and the Math skills required by the standards. It aims at imparting the required skills in an interesting and meaningful way for the student to ensure better understanding and retention. It caters to the varied learning styles of each child. This helps the child personalize the knowledge and boosts his confidence level. It brings about positive changes in the role of a teacher / student and the nature of student–teacher interaction in the classroom.

Key words: e-learning, multiple intelligence theory, memory maps, representation of content, instructional design, co-operative learning

1. Introduction

Mathematics as is taught in schools involves the teacher 'demonstrating' the stepwise solution on a board. Children in the class as a group are expected to learn math by observing the demonstration. Assumptions here are that the thinking pattern of the teacher is being replicated by the student in his /her mind as the teacher vocalizes what is being written on the board.

The erroneous premise is that all students in a class 'can' and 'should' think alike. In most schools children do not receive individualized instruction. If there is one subject that should be taught on an individual basis, it is mathematics. The majority of math classes consist of a teacher-led lesson directed at the whole class followed by individual practice and sometimes group-activity reinforcement. In the traditional board demonstration of a mathematical solution way of teaching, students often lose or fail to grasp the pattern behind the teacher's way of thinking. The use of metaphors, simile or analogies to make the underlying logic in mathematics more absorbable by the student has seldom found mention in educational psychology literature [1].

The work presented in this paper is a result of an attempt to find the answer to the provoking question "If the letter "A" triggers the image of an "Apple" and if the letter "B" stands for a "Boy", what association would a child make when he hears the expression $(a-b)^2$ for the first time?" [2]

The question was -how to provide learning experiences that use the student's strengths to interpret and analyze the mathematical information, and hence help students to discover meaning in the content to make learning more relevant. Howard Gardener's Multiple Intelligence Theory [3] was adopted as it had proposed not one but many types of intelligence in an individual. If multiple intelligence abilities could be utilized in a learning situation, it afforded greater chance of making the learning experience better.

1.1 The theory of Multiple Intelligences (MI):

Traditionally individuals were viewed as possessing degrees of intelligence, as measured by IQ or some test scores, usually made in school contexts, about school performance(the Piagetian view [4]). Modern theories of intelligence have allowed for a dynamic and multi-dimensional view of intellectual possession. One such theory "The Theory of Multiple Intelligences (Gardner, 1983)" has proposed the possession of multiple intelligences as a universal human characteristic for example: linguistic intelligence, logical-mathematical intelligence, bodily-kinesthetic intelligence, musical intelligence, spatial intelligence, interpersonal intelligence, intrapersonal intelligence and naturalistic intelligence.

Examples of learning patterns for some of these intelligences are:

a)**Visual / Spatial Intelligence:** Visual learners respond well to colors and images.
b)**Verbal / Linguistic Intelligence** : Verbal learners absorb information easily from written material.
c) **Bodily / Kinesthetic Intelligence:** To get the kinesthetic learner motivated, he or she needs to be touching, moving and manipulating objects.
d) **Interpersonal Intelligence:** Multi-player learning games are great for interpersonal learners

Traditional math instruction approach is geared primarily towards the logical-mathematical intelligence part, which is not necessarily an asset in all the students. Thus these other intelligences of all the students need to be tapped, in our quest to engender a "felt sense" in mathematics. For instance, a musically intelligent student may really break through on number pattern recognition when that pattern is translated to piano keys or rhythms [5], and a spatially intelligent student may get an "Aha!" from a lively diagram or even a mind map.

2. Field Study

Method

Mathematics periods of a primary local school was chosen for observing the interactions between the teacher and students while a particular lesson was completed. The class consisted of 40 students of V th graders. The study was done to find out what really transpires between the teacher, the students and the content floating between them [6]. How are the concepts communicated, understood and how children react to learning Math as an experience.

2.1 Field Study Observations & Analysis

The teaching methods are primarily of the following kind:

i. Teacher led classes:
    a. Role of teacher: The all knowledgeable
    b. Body language of students: Ready to ‘receive’ at the beginning of the class.
    c. Not interesting for non-participating students.
    d. Able to address only a section of the class usually less that one third.
ii. Demonstrations
    a. Much more interesting, but kind of like a museum. Child feels at a loss at not being able to be part of the concept, not able to interact as in play.

iii. PPT, Animations, Videos: When ever used are interesting, though these are

a. Easy to drift off (less attention span when the underlying concept is unclear)
b. Students not forced to think – not motivated to take part or get involved.
c. Listening and taking notes is difficult as flow of thoughts is discontinuous.

Therefore the question that rose was "How can a child personalize and internalize all the knowledge being demonstrated in front of her?"

In a mathematics class, teaching a topic can be divided into 3 parts:

i. Introduction /History: This gives motivation for the students to learn the topic. Cognitively this is equivalent to drawing attention
ii. Concept teaching: Actual teaching of the concept. This involves motivating the student to discover underlying pattern and structure thereby provide a pathway for thinking.
iii. Practice: Doing problems from books. This reinforces belief and ensures memorization not by rote but through understanding.

In all the above three stages, there is scope to use similes, analogies and metaphors. This ensures input of new knowledge and thus experience utilising multiple inelegance an individual has.

Based on the class room observation made earlier it was observed that most often the amount of time and importance given to the above three steps is in ascending order i.e. Introduction to the days topic is mostly ignored completely, the concept teaching is typically done in one class using a random method depending on the teacher (like paper cut outs, history, writing the symbolic formula (for eg: Pythagoras theorem); most of the teaching time and focus is on practice i.e. solving large number of problems from the book. It is assumed erroneously that practice makes the student perfect and error free.

It is posited in this paper that this ascending order of compounding the difficulty for the student should probably be in the reversed order starting with the introduction/history step. If the child is motivated his retention and efficiency increase many-fold throughout the duration of a topic. It is posited here that if the concept is ingrained in the student through utilizing multiple intelligence sensing then learning happens or else Mathematics may remain the most dreaded subject to many.

3. Application and development of CRIB

An E-learning package for Introduction & Concept teaching as the part of the Math class was developed incorporating novel framework that addresses multiple intelligence. In the process of conceptualizing a tool named as CRIB (Concept Reinforcement Idea Board) was developed. E- Learning affords addressing multiple senses. It is visually appealing therefore attention holding. It can be a fun experience through constant hand, eye movements. Simultaneous incorporation of different mediums such as video , music, animation that are possible in e learning packages free the student and the teacher of " one compulsory way to do things for all" constraint that comes from traditional class room setting. Role of virtual manipulatives [7] [8] in Math is a much researched area with positive results reported in literature. Many software tools are available as add on plug-ins .These can be naturally/easily embedded in an e-learning package.

3.1. Concept Reinforcement Idea Board (CRIB) – a proposal

CRIB (Fig 1) is a tool developed to help represent a concept in different ways by engaging multiple modalities and to reinforce the idea to cater to the varied learning styles.

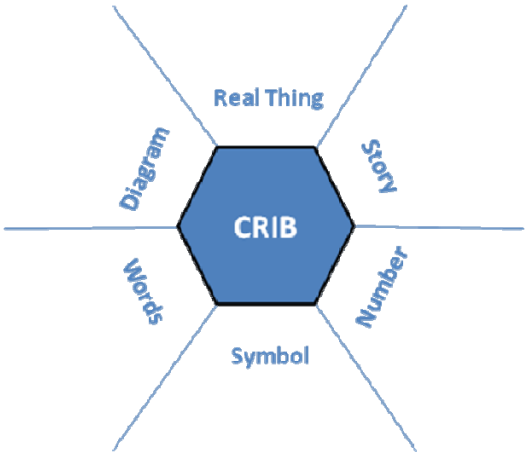

Figure.1 Concept Reinforcement Idea Board

The different components map the recommended Math deliverables with effective learning theories such as Multiple Intelligence.

Let's take a look at each component with an example concept of "Expansion of $(a-b)^2$ "

Real thing: Hands-on activity showing the concept.

The students take paper cut-outs to see how (a-b)2 and (a2 + b2 – 2ab) represent the same area.

Story: Word problem on real world situation.

A florist grows flowers in a square plot of sides 200m. One night Mrs Basu her jealous neighbor cuts down all her flowers at the borders, reducing the side by 50m. What is the area of plot now?

Words: Spoken mathematical statements and terms. *"a minus b times b minus a"*

Virtual: Interactive application, games, animation.

Diagram, **Number**, **Symbol** are self-evident. Geometric figures can also be used.

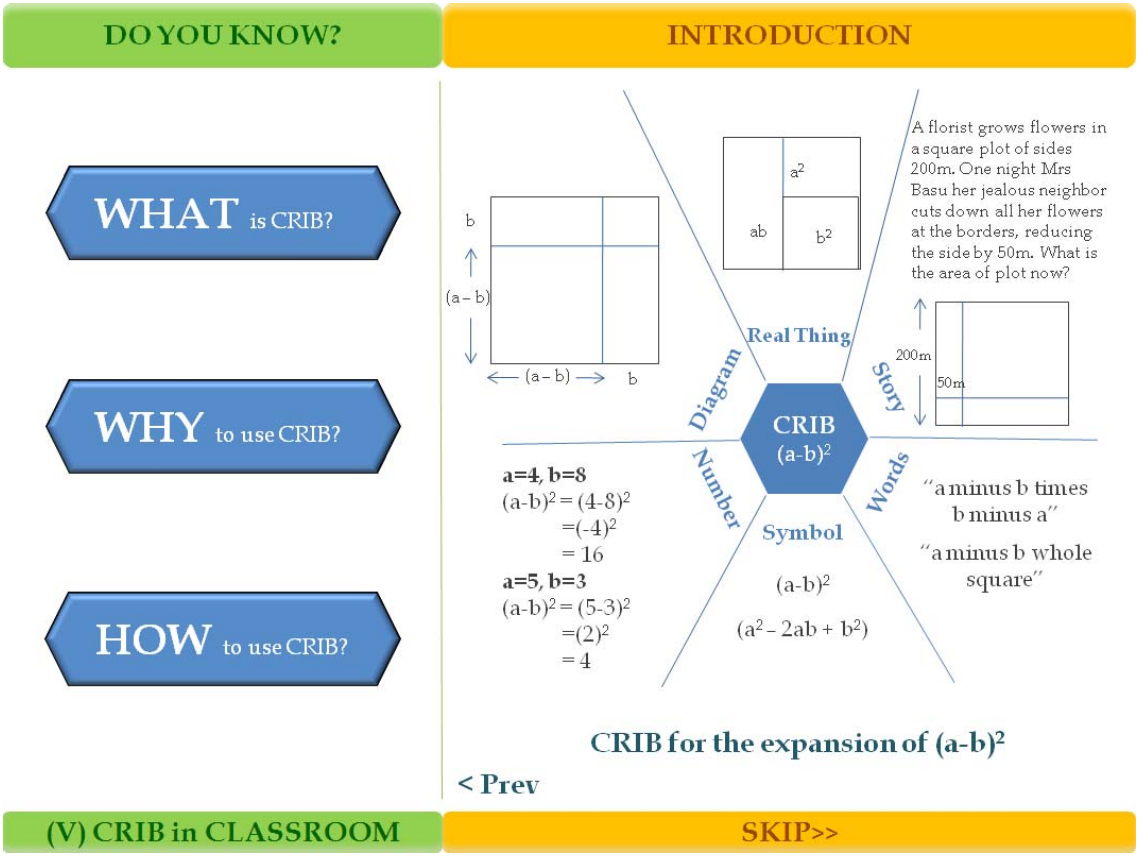

Figure 2 Fig illustrating use of CRIB for the expansion of an example in Maths: $(a-b)^2$

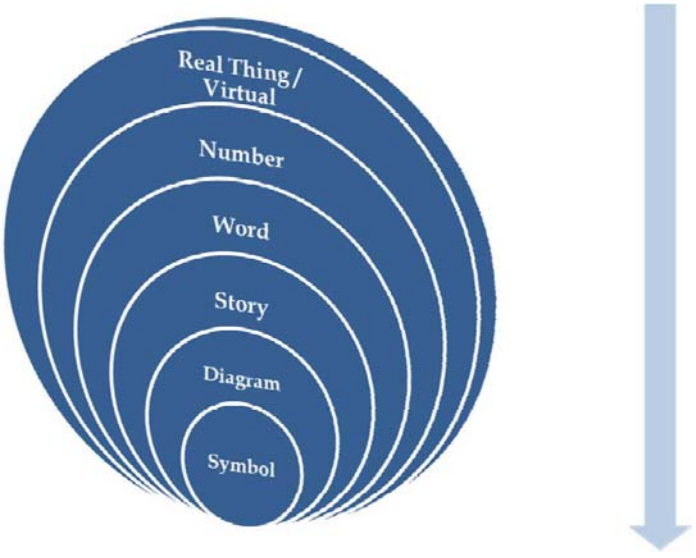

Figure 3 Hierarchical relationship of the Six Components of the CRIB

4. Discussions:

4.1 Scope and objectives of the CRIB frame work

CRIB aims at imparting the required skills in an interesting and meaningful way for the student to ensure better understanding and retention. It caters to the varied learning styles of each child. This helps the child personalize the knowledge and boosts her confidence level. It brings about positive changes in the role of a teacher / student as learners and the very nature of student–teacher interaction in the classroom. There is scope for embedding fun and play into Maths teaching and learning. anecdotes, stories , jokes ,riddles can become part of the student –teacher interaction the only limiting factor for doing so is the teacher's imagination.

Adopting CRIB as a framework has further advantages such as

Role of teacher:

a. Saves time since teacher doesn't have to write or draw everything. Also teachers may not have drawing skills in terms of aesthetics, accuracy and perspective.
b. Teacher can now focus on essentials – can spend more time on 'how to teach', time to observe students, give individualized feedback.

ii. **Role of student:** Active learning not passive learning anymore, independent, gains confidence and able to relate because more likely that he would find one of the modes natural to him.
iii. **Student – teacher interactions:** Customized, one-to-one even though surrounded by a group of students.
iv. **Student – student interactions:** More possibilities of peer interaction [9]. Someone gifted with (say good with hands) can now help someone who is not so good with hands-on work but maybe very good at manipulating numbers & symbols.

4.2 Suggestions for using CRIB in the classroom: -

The integration of this tool with the current teaching practices is highly subjective but following are a few suggestive ideas: -

For introducing and developing concepts (not for practice since it is time consuming).

Demo CRIB for a concept and then ask the students to do a similar one on their own.

Follow the suggested flow for the order of viewing / filling in the fields.

On-going and continual assessment tool to check student understanding.

Pre-assessment tool to identify learning preferences of each child.

4.3 CRIB as an e-learning package

CRIB has been used to develop an E- learning package – 'Maths for everyone'. A sample of the high fidelity prototype is shown in figure 4. The package can be used in a classroom by the Math Teacher to introduce a topic and then teach its relevant concepts using the CRIB (concept reinforcement tool) application in the package. Then the children are asked to assimilate the experience and repeat the learning on a CRIB drawn on a paper, this way it can be assessed as to how much really the concept has been internalized by the child and if he is facing a problem, the problem can be easily classified to be in one of the modalities and representation forms.

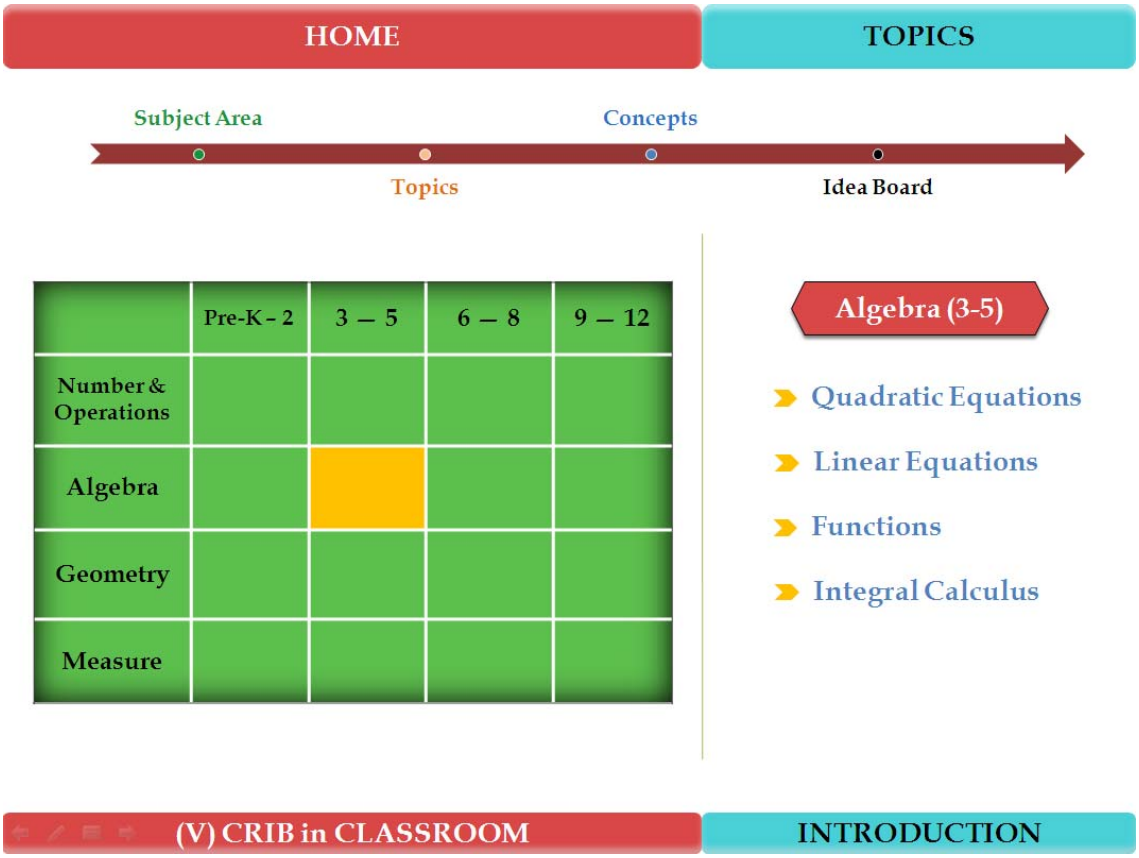

Figure 4 High Fidelity Prototype

CRIB could be developed for other subjects as well especially Science. Science instruction provides opportunities for simulations, demonstrations, activities, definitions, numerical which could be adapted easily from the current version.

Example in Science: Levers CRIB

1. **Introduction**

   A video showing use of levers in daily life like in an arm, spoon, bird beaks etc.

2. **Fields**

   a. Real Thing: Making a catapult.

   b. Diagram: Diagrams of 1st, 2nd and 3rd class levers labeling the type of lever, fulcrum, effort and load.

c. Definition: Proper use of terms Lever, Fulcrum, Effort, Load and Mechanical Advantage.

d. Numericals: Finding mechanical advantage offered for a given combination of load and effort.

e. Demonstration: See a car jack in action.

f. Virtual Manipulatives

i. Animation showing levers in action

ii. Interactive building of a simple machine involving levers.

5. Conclusions

Each child is unique in ways they think, learn and demonstrate their learning. These differences raise some critical questions for an education system:

• How to develop a teaching tool which would cater to the student differences?

• How to provide space for a child's own musings, experiences, questions, interests?

Using maths as a subject a framework named as CRIB was proposed based on the theory of multiple intelligence.

CRIB is not intended to replace the teacher, but merely to facilitate the teacher with the presentation of content and allowing more time for teaching and interacting with the child in a learning situation. CRIB can also be used as a frame work for structuring and developing E learning packages.

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