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Unorganized Cognitive Structures of Illiterate as the Key Factor in Rural e-Learning Design

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Abstract
Cognitive Structures and Linguistic Sequential Memory or Memory of Serial Order are not very well developed among illiterate people contrary to educated people. It affects the comprehension of abstract ideas and the usability of the system. Therefore the cognitive limitations of illiterate must be considered for instructional design and user interface design to achieve better results from rural e-learning. The paper also throws light on the reasons behind the unorganized cognitive structures of illiterate.

Keywords
Cognitive Structure, Linguistic Sequential Memory, Memory of Serial Order, Usability, Instructional Design, Rural e-Learning, User Interface Design, Illiterate Subjects

1. Introduction
Literacy means not just reading and writing skills but it also refers to a set of cognitive skills that are necessary for knowledge acquisition, structuring, comprehension and learning. Such skills can exist independent of literacy also but then they are not well groomed. Formal schooling helps in developing the cognitive skills among literate people (Education For All: Global Monitoring Report, 2006). With education one is able to build more complex, domain specific and rich cognitive structures.

This paper presents a case study that reveals some of the cognitive habits, characteristics and limitations of illiterate people. Though the author has viewed the cognitive structures from the perspective of rural e-learning, the findings of this paper are useful to general instructional design and user interface design. It will be helpful in improving system's usability.

1.2 Cognitive Structures
Cognitive structures are patterns of physical or mental action that underlie specific acts of intelligence and correspond to stages of child development. There are four primary cognitive structures (i.e. development stages) according to Piaget (1929) namely Sensory Motor, Pre-operations, Concrete Operations and Formal Operations.

In the final stage of Formal Operations (during the age of 12-15 years of child), thinking involves abstractions. The case study presented in this paper throws light on the Formal Operations in illiterate.

Cognitive structure is like a knowledge structure where the nodes are representing more or less abstract entities derived from percepts (Kulakov, 2002). It is the mental hierarchical representation of world, which helps in conceptual organization, comprehension and retrieval of information. Such cognitive structures can be built more effectively through linguistic skills.

Figure 1.0 shows a sample cognitive structure of 'house'. Let us try to understand how the cognition takes place. Every educated individual brought up in an urban environment will have more or less similar cognitive structure of 'house'. It is basically the mental representation of the world. If you were asked to add more details to figure 1.0, I am sure that you would identify sub-elements like study room, toilet, gallery, veranda, garden, terrace and so on, which are presently missing. The reason why you could do this is because you have a much richer cognitive structure of 'house' encoded in your brain. You compared figure 1.0 with your cognitive structure of 'house' to find out the missing elements.

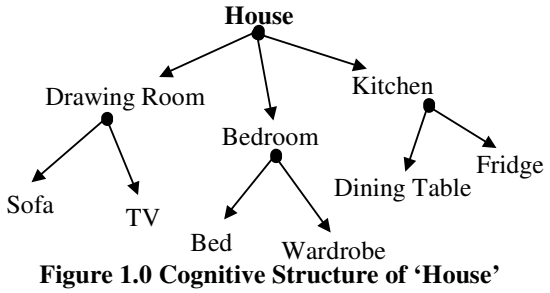

Figure 1.0 Cognitive Structure of 'House'

The moment one mentions about 'house' we infer the sub-elements in the hierarchical structure as shown in figure

1.0. You don't require the sub-elements to be explicitly stated, they are implied in the concept of 'house'. Each sub-element like television or fridge also has a complex hierarchical structure but one unfolds it as needed. Humans have the tendency to build such structures cautiously or incautiously. Education cultivates this as a habit. It gives you the ability to understand abstractions and decipher the implied information quickly.

Language plays a very important role in memorizing the cognitive structures. Each world, presently the 'house', has its own spatial order and conceptual hierarchy. But it can't be remembered unless each node in the hierarchy is properly named.

Name is essentially a word formed out of a set of letters in a particular language that can be pronounced with a series of sounds. As a reciprocal action to the pronunciation of the word, brain retrieves an associated image (Russell, 1921).

One requires training for memorizing the spatial order and the names of each node in the cognitive structure. It helps in remembering complex information in terms of abstract concepts, classifications, sub-levels and elements. Also, there are purely conceptual cognitive structures, which are totally abstract and do not have associated images.

2. Cognitive Test of Illiterate Subjects

I have been performing cognitive tests with illiterate subjects from rural parts of Maharashtra state in India for 3D Watershed Game Development project. The objective of the proposed 3D Game is to teach watershed management techniques to illiterate villagers. My aim behind the cognitive testing of illiterate subjects is to define their cognitive abilities and limitations. I propose to use this knowledge as inputs in the instructional design, game design and user interface design.

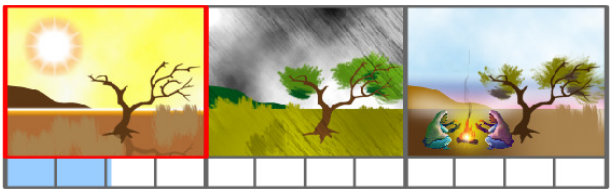

Figure 1.1 Seasons Indicator

In the proposed 3D Game, we have to indicate the progress of time to illiterate players as watershed development takes 3 to 4 years time. We need to represent this long duration in the game-time of 2 to 3 hours. Initially, we considered 'Calendar' to indicate the progress of time, but rejected it, as illiterate villagers cannot read months or dates. Therefore, we designed the 'Seasons Indicator'; which has visual depiction of three seasons predominant in India namely summer, rainy and winter. As shown in figure 1.1, each season is fragmented into 4 segments to represent months. Animated progress bar moving through the segments of months indicated the progress of time.

We invited a mix of illiterate and literate subjects (consisting of both men and women) for the proposed cognitive test. We wanted to find the comprehensibility of 'Seasons Indicator'. The subjects belonged to mixed age group starting from 20 years to 60 years. We expected the subjects to recognize all three seasons depicted in the 'seasons indicator' and approximately calculate the progress of time in terms of months. Each subject was tested separately to avoid influence of opinion. We had no prior knowledge of the *unorganized cognitive structures*.

3. Unorganized Cognitive Structures

The response of both illiterate and literate subjects is given below.

3.1 Response of Illiterate Subjects

When we asked each subject to describe what they saw in the visual, to our surprise, 95% of illiterate subjects described the visuals as under.

First Visual: Bright sun, dry tree trunk, yellow grass

Second Visual: Raindrops, black clouds, wind, green grass, tree with green leaves

Third Visual: Morning, cold, campfire, women, tree

The illiterate subjects accepted the visual depiction of each season when explained later. Having understood the seasons, they could infer the four segments as representations of months and interpret the progress of time by looking at the animated progress bar.

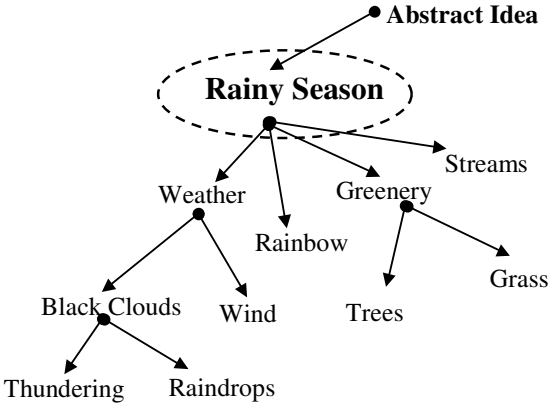

Figure 1.2 Cognitive Structure of Rainy Season

3.2 Response of Literate Subjects

100% of literate subjects precisely recognized the seasons as summer or rainy or winter. They could immediately estimate the progress of time.

3.3 Analysis of Response

The cognitive structure of rainy season is roughly as under-

The illiterate subjects described each element in the visual but could not summarize the overall cognition as 'summer' or 'rainy' or 'winter'. It is possible that the graphic / symbolic / simplified visual of each season lacks sufficient clues for recognition of overall abstract idea.

In literate subjects, we find that the cognitive structures are properly built and summarized through abstractions. Therefore, all of them could quickly recognize the visual as 'summer' or 'rainy' or 'winter' without describing each element in the visual.

As per the Piaget's four stages of cognitive structure, it is apparent that the illiterate subjects have not fully reached the fourth stage of Formal Operations in which thinking builds abstractions. Also it is evident that the illiterate subjects have not organized their knowledge in a hierarchical structure. It is arranged in an unstructured or planer fashion.

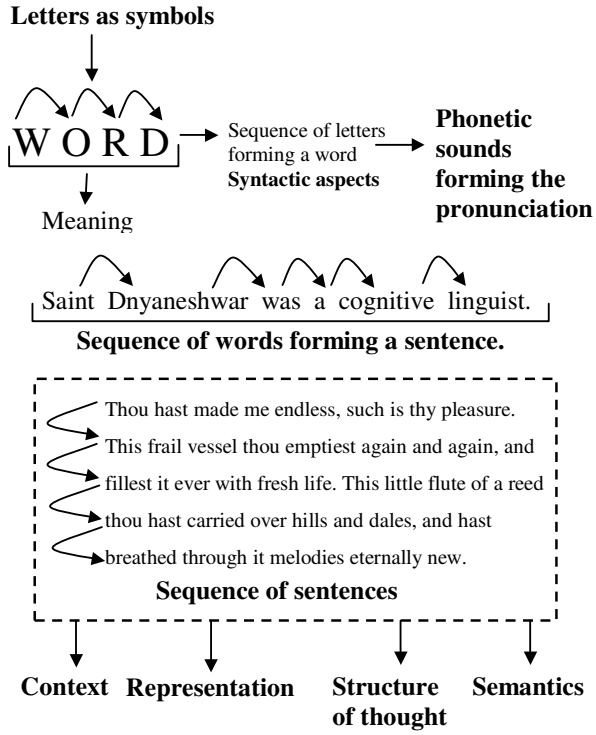

Figure 1.3 Activities of Linguistic Sequential Memory

4. Linguistic Sequential Memory

The educated people are quite effective in using Linguistic Sequential Memory also known as Memory of Serial Order (Dennis, 2003) during thinking, conversations and computer usage.

Linguistic sequential memory is cultivated to remember visual symbols, phonetic values, content structure, semantics, context of application, other references related to verbal expression, etc. as shown in figure 1.3.

It is obvious that the linguistic sequential memory is not likely to be well developed among illiterate people if compared with educated people.

Children in the age group of 3-5 years do not have sensitivity for order in which a spelling is written. I observed that children are initially comfortable with "adn, nda" as the spellings of "and". For them the presence of specified letters is good enough, irrespective of the order in which they are arranged. It requires special efforts to develop order sensitivity among children.

Linguistic sequential memory helps in fragmenting, defining and structuring of cognitive structures.

Table 1.0 explains how the cognition process is different in literate and illiterate subjects in the context of our experiment.

Table 1.0 Cognition Process

Sr. Nos.	Literate Subjects	Illiterate Subjects
Step 1.	Sensory Stimulus (Visual of Seasons Indicator)	Sensory Stimulus (Visual of Seasons Indicator)
Step 2.	Remember the sub-elements (details) of the stimulus in Short Term Memory (STM)	In many cases, not all details are taken into account or remembered using STM. Each is directly recognized using LTM.
Step 3.	Match the details with existing knowledge stored in Long Term Memory (LTM)	
Step 4.	Invoke the connections in the particular cognitive structure	As the existing knowledge is unstructured and unconnected in many places, overall cognition of the abstract idea (Rainy season) does not happen.
Step 5.	Cognition of overall abstract idea (Rainy Season)	

5. The Reasons

The reasons of unorganized cognitive structures prevalent among illiterate subjects are given below. We do not intend to say that educated people always have well

organized and fully evolved cognitive structures. **The problem described in this paper is prevalent among both type of subjects but it is more prominent in illiterate.**

5.1 Lack of Adequate Vocabulary

The reason why illiterate people are unable to build complete or complex cognitive structures is due to lack of adequate vocabulary. As the nodes in the cognitive structure need to be appropriately named for memorization and then recall.

5.2 Inability to Understand Abstract Ideas

It is also due to inability to understand concepts and abstract ideas.

5.3 Ineffective Use of Memory

The ability to use Short Term Memory (STM) and Long Term Memory (LTM) (Baddeley, 1996) also plays a crucial role in enriching the cognitive structure with finer details. Also, the linguistic sequential memory or the memory of serial order is very weak.

5.4 Disorganized Knowledge

Having remembered the required details, one needs to classify, connect and structure the knowledge. This ability is nurtured through education. In case of illiterate people, cognitive structures are not adequately evolved and the knowledge is quite scattered.

6. Problem of Knowledge Structuring

Knowledge structure has more and more abstract ideas as one moves upward in the hierarchical order. As one goes downward in the hierarchical order things are more concrete and specific.

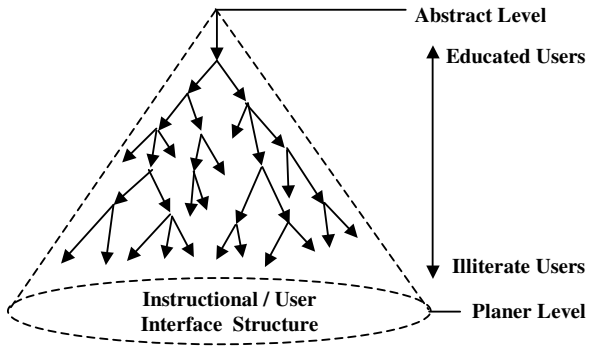

Figure 1.4 Problem of Knowledge Structuring

For example, 'living' and 'non-living entities' are the most abstract divisions of the world that can be placed at the top of the conical structure shown in figure 1.4. It is obvious that many illiterate people and children will have difficulty in understanding these concepts.

As shown in figure 1.4, the illiterate users are likely to have more planer / scattered / unstructured knowledge than the highly structured knowledge of educated users. Therefore if the instructional design or user interface design of your e-learning application is highly structured, it is bound to introduce abstract ideas. As illiterate people have difficulty in understanding abstract ideas, the e-learning system is not likely to succeed.

7. Conclusion

The sensory stimulus, cognitive structure and memorizing capabilities (STM, LTM and Linguistic Sequential Memory) of illiterate in a particular context must be studied before designing the multimedia content, instructional design and user interface.

Highly structured information is bound to introduce abstract ideas. Or if the information is structured with abstract ideas then one must test whether the rural subjects are able to comprehend them in the desired manner.

The findings of this paper will be useful in structuring of website information. Abstract hierarchical structure helps in reducing the number of hyperlinks on the homepage but probably it might be affecting the usability of website. Laymen or non-specialists (with respect to the topic of website or e-learning application) are likely to explore more at the planer level of information, as we saw in illiterate subjects, and not at the abstract level.

The study of cognitive structures will be extremely helpful in improving the usability of e-learning applications and user interfaces.

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Dr. Dinesh S. Katre presently heads the National Multimedia Resource Centre of C-DAC, Pune, India. He has Ph.D. in Human Computer Interaction (HCI). He has conceptualized and successfully implemented numerous sponsored R&D projects that deal with digital library for Indian heritage, low cost multimedia content creation, multimedia authoring, e-learning and 3D game development. He has special interest in cognitive modeling, cross-cultural study of user interface, visual cognition, interface metaphors and psychology of software users.