

Data Mining in Cognitive Science: An Interdisciplinary Approach

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ABSTRACT: Every human is unique in their thought process, which makes them as smart or hard workers. Cognitive process is a relationship between thinking, learning, intelligence and knowledge. In this study, we discussed about human memory characteristics, learning and their intelligence. In a research perspective, the relationship between data mining and its applications in cognitive science is mainly focused. In this process, we come up with educational data mining, which is about learners and their multiple intelligences. This research focuses on the application of different algorithms of data mining, using the technique of Clustering, classification and association in educational data mining in relation to the inner cognitive process of human. Therefore, by knowing the multiple intelligences in students, faculty may be able to contribute to the conditions in the learning environment, facilitating to achieve the learning objectives of the students.

KEYWORDS: Cognitive, memory, brain dominance, intelligence, data mining.

I. INTRODUCTION

Cognitive Science:

Cognitive Science is a theory relating working memory characteristics and the design of instructional systems. Theories of the architecture of human memory make a distinction between long term memory and short term memory. Long term memory is that part of memory where large amounts of information are stored (semi-) permanently, whereas short term memory is the memory system where small amounts of information are stored for a very short duration. The original term “short term memory” has since been replaced by “working memory” to emphasize that this component of memory is responsible for the processing of information. A series of studies have found that individual working memory performance correlates with cognitive abilities and academic achievement. Human memory is neither a single entity nor a phenomenon that occurs in a single area of the brain. The architecture of the brain's memory can be organized into (a) Sensory Buffer Memory (SBM) (b) Short-Term Memory (STM) (c) Long- Term Memory (LTM) and (d) Action Buffer Memory (ABM).

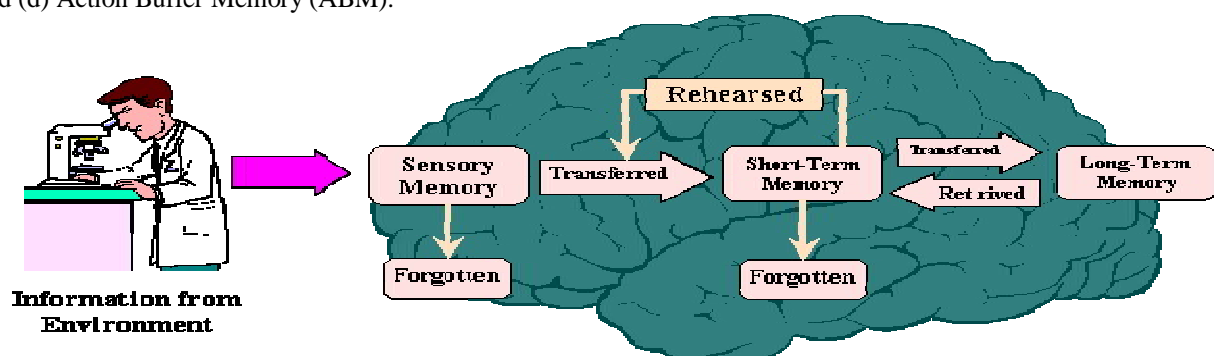


Figure 1: Architecture of Brain's memory

Cognitive load theory categorizes three different types of contributions to total cognitive load.

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1. Intrinsic cognitive load
2. Extraneous cognitive load
3. Germane cognitive load

Intrinsic cognitive load relates to inherent characteristics of the content to be learned, extraneous cognitive load is the load that is caused by the instructional material used to present the content, and finally, germane cognitive load refers to the load imposed by learning processes.




Figure 2: Classification of Cognitive Load

Learning and Memory:

Generally, Learning can be defined as a change in behaviour as a result of experience. Learning happens in the brain. Our ability to learn and consciously remember everyday facts and events is called *declarative memory*. *Semantic memory* is a form of declarative knowledge that includes general facts and data. Our memories of specific personal experiences that happened at a particular place and time are called *episodic memories*.

The brain receives a constant stream of information as electrical impulses from neurons in the sense organs. The first thing it does is to determine whether the information warrants attention. Brain requires stimulation and connection to survive and thrive. But if it is novel or important, the brain amplifies the signals, causing them to be represented in various regions. If this activity is sustained for long enough, it will result in a conscious experience. In some cases, thoughts are taken one step further, and the brain instructs the body to act on them, by sending signals to the muscles to make them contract. Different parts of the brain performs different actions as they are shown below:

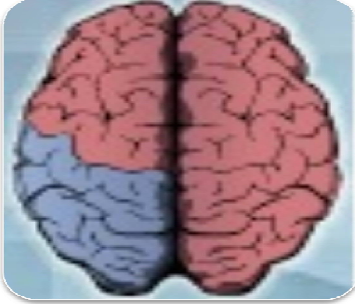
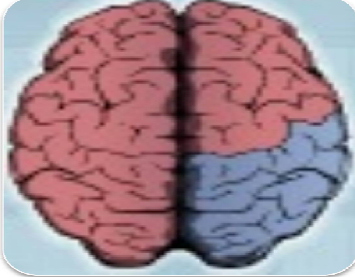
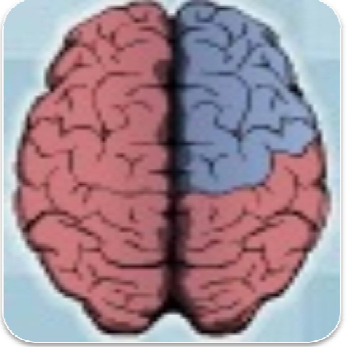
Portion of the Brain	Image	Functionality
Frontal Left		Individuals are adept, not only at linking ideas together by means of their logical connections, but also at separating entire systems into their component parts. They record information by key concepts, allowing for easier transfer and application from one area or field to another, and are most interested in general operational principles, which assist in the effective use of resources and facilitate technical problem solving and decision making.

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Basal Left		Individuals with a preference for this mode of thinking process by following a pre-established or pre-programmed order, which has been loaded earlier and can simply be run. They are attentive to details, extremely effective at executing routine, sequential tasks, and most highly motivated to learn procedural applications, which have a clear and immediate use and are presented to them in an organized, step-by-step manner.
Basal Right		Individuals who prefer the Basal Right/Feeling mode are adept at reading non-verbal communications. Sensitive to rhythms and subtle shifts in mood, shade or tone, they are highly attuned to what is “going on” with others and they put a premium on facilitating harmonious interactions. Not surprisingly, they are unsurpassed at monitoring the emotional climate of an individual or group.
Frontal Right		The Frontal Right brain is a spatial, internal image generating brain, which processes by scanning for broad stroke patterns and by making connections between seemingly unrelated occurrences. It thinks metaphorically and abstractly and is far more interested in concepts than in actual events. Novelty (especially, new ideas and concepts) is highly appealing to this brain, as are visual images. Its greatest liability is that since it is so focused on future possibilities, it may well overlook actualities or “lose touch with reality”.

Everyday phenomena have something commonly called “learning”, and learning results in ‘total’ or ‘partial’ reconstruction of a past experience. Learning is a process in which neurons fire together to produce a particular experience. Every time neurons are fired, the learning is altered so that they have a tendency to fire together again. The subsequent combined firing of the neurons reconstructs the original experience, producing a “recollection” of it. The act of recollecting makes the neurons involved even more likely to fire again in the future. So repeatedly reconstructing an event makes it increasingly easy to recall. *Beta* waves are the ones the brain produces during the day i.e., your working, travelling, etc. *Alpha* waves are a bridge between your conscious and subconscious minds, and they help learning. This is a relaxed state which can be induced via meditation. *Theta* waves are produced as you’re drifting off to sleep and *Delta* waves are produced in deep sleep and deep meditation. Each wave has its own frequency and vibration, with each wave being slower than the previous one.

Learning and Intelligence:

Learning involves making new connections between clusters of neurons in different parts of the brain. This builds up the brain, making it fitter. For example, practicing spatial skills such as finding your way around a city has been shown to increase the size of the rear hippocampus. The more the connections you create, the better you can use what you learn and the longer it takes you to forget it.

Intelligence is the ability of learning from experiences and previous knowledge to adapt in a new situation. Intelligence refers to the ability to learn about, learn from, understand and interact with one's environment. Along his exclusive

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study, Howard Gardner developed number of concepts related to cognitive abilities of people. Gardner established the notion of multiple intelligences long back and These concepts now came to be ratified in education for the 21st century. These multiple intelligences include linguistic, logical, bodily kinaesthetic, visual and spatial, musical, interpersonal (social) and intrapersonal intelligence, as shown in the below table:

Multiple Intelligences	Features
Nature Smart(Naturalistic)	Ability to understand the environment, the ability to categorize plants, animals and other objects in nature
People Smart(Interpersonal)	Ability to work and collaborate with others, Respond appropriately to the moods of others
Number Smart(Logical/Mathematical)	Problem solving, Comfortable with the signs, symbols, abstract and mathematical concepts
Picture Smart(Spatial/Visual)	Sensitive to images and videos, Capacity to perceive and create mental images
Self Smart(Intrapersonal)	The capacity to be self-aware, To discern in tune with inner feelings, values, beliefs, and thinking processes
Body Smart(Bodily-Kinaesthetic)	Handle object skilfully, Ability to control one's body movement,
Music Smart(Musical)	Sensitivity to the sounds, Capacity to pick rhythm and tone
Word Smart(Linguistic)	Verbal Skills, Ability to read and communicate either orally or in writing

Table 1: Multiple intelligence

II. DATA MINING IN COGNITIVE SCIENCE

Han and Kamber [1] described that data mining software allow the users to analyse data from different dimensions, categorize it and summarize the relationships which are identified during the mining process. Alaa el-Halees [2] in his research work, described that Data Mining can be used in educational field to enhance our understanding of learning process to focus on identifying, extracting and evaluating variables related to the learning process of students. Hijazi and Naqvi [3] conducted a study on the student performance by selecting a sample of 300 students (225 males, 75 females) from a group of colleges. The hypothesis that was stated as "Student's attitude towards attendance in class, hours spent in study on daily basis after college, students' family income, students' mother's age and mother's education are significantly related with student performance" was framed. By means of simple linear regression analysis, it was found that the factors like mother's education and student's family income were highly correlated with the student academic performance. Galit [4] gave a case study that use students data to analyse their learning behaviour to predict the results and to warn students at risk before their final exams.

Thinking is an action of the decision-making process through mental images and concepts. Intelligence is an ability to understand complex things and acquire knowledge through their experiences. Reductionist and emergentist approaches provide contrasting views about the functioning of the brain. The former seeks basic elements and lower level explanations. Whereas, later seeks for the higher level organization of cognitive actions [5]. Howard, Earl Gardner proposed Multiple Intelligence (MI) theory initially with seven intelligences, in the second edition having eight intelligences, in the third edition having nine intelligences and in the last edition ten intelligences. Finally, he argued that the packages included into intelligences are independent of one another [6]. In the progress of research work, Katherine Benziger based on Carl Gustav Jung's typology [7] has reaffirmed the link between cognitive thinking and neurosciences and named this Psychological instrument as Benziger Thinking Style Assessment (BTSA). Lakshmi Dhandabani and Rajeev Sukumaran in their research study conducted an experimentation on more than 500 undergraduate computer science engineering students to find the correlation analysis between Brain Dominance and Multiple Intelligence[8].

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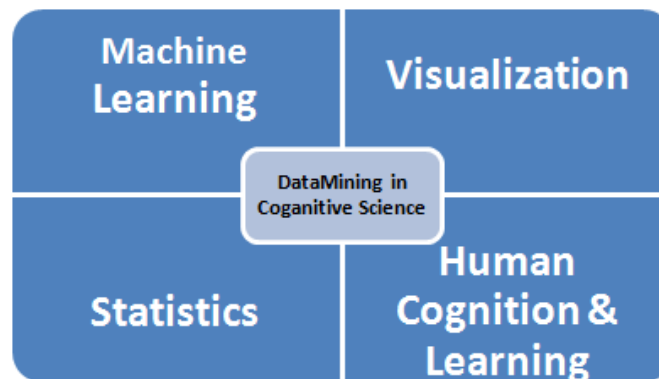


Figure 3:Data Mining in Cognitive Science

This research is carried out in order to understand the psychological traits of learners, in order to fill up the gap between learning technology and pedagogy. BTSA is a tool to understand the diverse thinking preferences of the 21st century students, to help them gear up their aspirations to learn and succeed in their lives.

The prime objectives of this study are:

- (a) Identifying the brain dominances of the learner's
- (b) Identifying the multiple intelligences of the learner's
- (c) Applying correlation measure between brain dominances and the multiple intelligences.
- (d) to provide optimistic approach to the learner not only in their education but also for their near future.

III. EDUCATIONAL DATA MINING IN CORRELATION WITH BRAIN DOMINANCE AND MULTIPLE INTELLIGENCE IN LEARNERS

Educational Data Mining (EDM) is a new trend in the data mining and Knowledge Discovery in Databases (KDD) field which focuses in mining useful patterns and discovering useful knowledge from the educational information systems, such as, students performance, admissions systems, registration systems, course management systems (moodle, blackboard, etc...), and any other systems dealing with students at different levels of education, from schools, to colleges and universities. Educational data mining is an emerging research area with a suite of computational and psychological methods and research approaches for understanding Lower order and higher order Thinking skills in relation to the correlation analysis between brain dominance and multiple intelligence. Computer-supported interactive learning methods and tools have opened up opportunities to collect and analyse student data, to discover patterns and trends in those data, and to make new discoveries and test hypotheses about student cognition. The main goals of education data mining are :

- To predict students future learning behaviour
- To improve domain models that characterize the content that to be learned and provides optimal instructional sequences
- To study and analyse the effects of different kinds of pedagogical support that can be provided by learning software
- To make use of advanced scientific knowledge in developing Learner - Centric approach among learners.

IV. CONCLUSION

Cognitive Science is an Interdisciplinary approach. The relationship between data mining and its applications on learners in various courses results a research in Education Data mining in relation to Cognitive science. In this analysis, we analyse learners behaviour, impact of past incidents, their thought process, brain dominance, emotionality

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their multiple intelligence and so on. This research also focuses on the application of different algorithms of data mining, using the technique of Clustering, classification and association in educational data mining in relation to the inner cognitive process of learner. Therefore, by experimental analysis, faculty may be able to contribute to the conditions in the learning environment, facilitating to achieve the learning objectives of the learner.

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