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AN EMPIRICAL RESEARCH ON MULTI-DISCIPLINARY LEARNING CAPABILITY THROUGH MNEMONICS

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ABSTRACT

Growing massive need for enhanced learning capability through the use of useful teaching pedagogy is a very big challenge. In this paper, we conducted empirical research to understand issues and challenges in the applications. We used different teaching pedagogy through mnemonics in learning vocabulary, calculus and numerical computations on 16 random sample of Bachelor of Technology students. The issues and challenges are inferred from descriptive statistics. The findings are interesting to note with regards to different subjects (English and Mathematics). The use of mnemonics for teaching the multi-disciplinary subject is questionable and insightful. A very good scope of further research in this area is highlighted to extend the scope of understanding.

KEYWORDS: *Determining Multi-Disciplinary Learning, Statistical Test on Learning through Mnemonics*

1. INTRODUCTION

One of the most dynamic functions of brain is to memorize facts, figures, people, places, information, etc. Memory is that territory of mind which not only encodes information but also functions as a repository of the encoded information. We perceive many things in our day to day life which directly or indirectly leave an imprint on our mind. The urge of learning is infinite and so is the ocean of information where we encounter thousands of facts and details on various topics. Whenever we come across a novel entity our inquisitiveness to unravel the unexplored phases of that entity gets increased. Our curiosity makes us receptive and with rigorous efforts we yearn to achieve a certain level of excellence in it. It is noticed till the time our engagement with the task remains persistent we obtain desired result. As soon as the task becomes another accomplishment the verbal cues and relevant information start fading. In other words we start forgetting facts and information associated that helped us to complete a particular task in the past. The onset of the new goal brings new information and the cycle moves on like this. Often memory is broadly divided into two major parts: short term memory and long-term memory. Short-term memory phases out as soon as the goal is achieved for instance a student prepares something for his assessment as soon as the assessment is over the stored facts and information start fading and after some time they no longer remain a part of active memory. Longterm memory stays longer and serves as a powerful tool to accomplish many tasks in future. For longterm memory people use different techniques and strategies so that the information brain has stored through memorizing should remain there for a longer period of time.

Explicit and implicit functions of memory are also known as declarative and non-declarative systems (Squire, 2009). The *Declarative* or *Explicit Memory* is the conscious storage and recollection of data (Graf & Schacter, 1985). Under declarative memory resides *semantic* and *episodic* memory. Semantic memory refers to memory that is encoded with thespecific meaning (Eysenck, 2012), while episodic memory refers to information that is encoded along a spatial and temporal plane (Schacter& Addis, 2007; Szpunar, 2010). Declarative memory is usually the primary process thought of when referencing memory (Eysenck, 2012). Non-declarative or implicit memory is the unconscious storage and recollection of information (Foerde et al. 2006).

A robust, multi-disciplinary and everlasting memory is certainly a bedrock of achieving excellence in any field. Memory with high levels of multi-disciplinary learning capability provides us the ability to recall, retain various experiences and information from past and helps us to adapt in present in different instances. Etymologically, the modern English word ‘memory’ comes to us from the Middle English *memories* which in turn comes from the Anglo-French *memoires* or *memories* and ultimately from the Latin *memoria* and *memory*, which means ‘mindful’ or ‘remembering’.

A lot of research has been conducted in the field of memory with learning ability among various capabilities (Anthony & Knight, 1999). Researchers and scholars have time to time devised and improvised mnemonics to enhance an individual’s memory (Higbee, 1987), (Higbee, 1985). It is known that Mnemonics use elaborative keywords, retrieval cues and imagery as tools to encode any information in such an effective manner that these tools assist an individual to store the information for a longer period of time where retention is easier (Levin, 1983), (Atkinson, 1975). Ancient Greeks and Romans believed that memory is of two types: natural memory and artificial memory. Natural memory is inborn and varies from person to person (Hayes, 1984) whereas; artificial memory can be enhanced and improvised through certain mnemonics (Mastropieri et al. 1985). Mnemonics thus help a person to memorize multiple things easily and in a long term.

One such Mnemonics is ‘Memory Palace’ which is also known as Method of Loci (Qureshi, 2014). The Greeks and Romans also used mnemonics for effective memory (O’Keefe & Nadel, 1978). They used place or places to remember certain information. The Memory Palace relies on the fact that we are good in remembering places we see every day. Among all senses humans learn more through seeing things and visuals stay in our memory for a long time. Sometimes even a place we visited and got enthralled because of its magnificence stays in our memory for a longer time. Such place can be used to create a memory palace. In order to make the best use of Memory Palace as a mnemonic we generally choose a place we see every day as we are familiar with each and every details of that place. Memory Palace works in few steps: First the person has to decide a place he/ she is familiar with. The effectiveness of this strategy based on an individual’s ability to mentally see and walk through that place even when he is not present there. This place can be a person’s house, the street he lives in, the building where he works etc. The next step is to analyse the place methodically. Each and everything placed or positioned there, should be clearly memorized. When an individual enters that place he should be able to see things in their correct order. The next step is to imprint the place in the mind. Those who are quick visual learners they don’t take much time to memorise even the minute details of the place. Moving ahead the next step is to associate those things one wants to memorise with the objects he can see at that place. For instance a person wants to memorise the titles of the books, he can use his study room to memorise the names. He can associate each title with the objects he can see in the room. The final stage is to visit one’s memory palace. Once things are associated and the person has memorised them then as soon as he mentally visits the place those attached things will automatically appear in front of his eyes. The effective use of Mnemonics help use information already stored in long-term memory to make memorisation an easier task. Mnemonics like Memory Palace is highly effective in memorising things first time.

On the other hand, considering mnemonics for learning arithmetic calculation and University level mathematics is a very challenging proposition. Some research has been done which illustrates the effects of process mnemonic (PM) instruction on the computational skills performance of 13- to 14-year-old students with mathematics learning disabilities (Manalo et al. 2000). The paper by Allinder (1996) earlier, explored the effect of differential implementation of curriculum-based measurement (CBM) on math computation achievement of students with mild disabilities. However, it is noteworthy that children's capability on learning basic number mathematics is examined by (Bana & Korbosky, 1995) among primary school with various memory challenges. It is presently completely unknown that how adults behave in general, using Mnemonics in learning literature and technical subjects like arithmetic, higher mathematics at the same time. Higher Mathematics is very visual at higher level learning. It is hard to differentiate between visualization of abstract mathematical formulae and visual mnemonics used to learn the concepts. The present paper sets scope for this multi-disciplinary research and statistically examines experiment conducted in two stages in this regard on 16 Bachelor of Technology students at the University level.

2. MATERIALS & METHODS

2.1. Study Scope

The retrospective literature review was done to define scopes of this study setting. Some notable works are reviewed below:

The usage and applications of Mnemonics vary from person to person of different age groups. Mnemonics are devised by the educators keeping the learning objectives and outcomes in mind. The most receptive and adaptable mnemonics are those which can be easily understood and used. Mnemonics must be used according to the learning need of the learners and hence should be introduced at the appropriate time. In order to achieve desired outcome mnemonics should be incorporated in the teaching lessons in such a manner that they help the learners to enhance their learning levels.

The paper by Scruggs et al. (2010) highlights the usage of mnemonics to help disabled students. The paper by Manalo et al. (2000) states the effect of Process Mnemonics (PM) was more on trained students showing greater computational capability than on untrained primary school students. The application of mnemonics was checked on the students who suffered from the problems such as emotional and behavioral disabilities, mild mental retardation. Content areas include elementary social studies, elementary reading vocabulary etc.

In the other paper, the authors (Scruggs & Mastropieri, 2000) tried to use different mnemonics as strategies to overcome one of the common problems amongst the students which are academic content learning.

By using research integrating techniques this paper makes an endeavor to ease out the process of memorizing academic content. One of the research studies was conducted on eighth-grade students which have been discussed in the paper (Morrison et al., 1987)where the students were divided into four groups. Each group was given a different instruction to read a passage that described dichotomized attributes of nine North American minerals. One-fourth of the students was given some of the instructions to use mnemonics along with some keywords and mnemonics illustrations of the content to read the passage, one-fourth of the students was given keywords and further instructed to create their internal mnemonics. One-fourth of the students was guided to create their own keywords and internal images and rest of the students were encouraged to create and use their own style or method of reading the content of the passage. Those students who were given mnemonic keyword and illustrations showed the most encouraging results in terms of comprehending and recalling the mineral attributes as compared to the other three groups.

In the paper (Bellezza et al., 1978) the method of loci has been used and experimented to see the results. An earnest attempt was made to create a mnemonic device. It is discussed in the paper that method of loci actually acts in sync with natural memory. This was observed by using familiar loci provided by the subjects to make learning incidental. It was concluded that the recall of the verbal cues made by the subjects relied on the loci that were associated with the verbal cues and hence loci clues had helped the subjects to recall their verbal cues.

In another study (Nairne et al., 2005) the mnemonic effects of an initial recall on later recall in an immediate memory setting was studied and examined. In the experiments, the passage of time acted as a constraint. The results indicated that when participants initially recalled an item immediately preceding the target, target recall improved.

The article (Mastropieri et al., 1989) discusses a model for reconstructing associative learning tasks and also highlights the usage of pictorial presentations to provide more meaningful and concrete learning to deal with a variety of subjects. This model can be used to help disabled and handicapped learners to make learning easy for them. Broadly mnemonics are used to make memorization easy so that anxiety of learning and memorizing things can be alleviated in a study by Mocko (2017)the effects of using mnemonics was assessed.

A large number of university students were put on task to examine whether the use of mnemonics helped them to reduce their stress level while preparing their exams. In another article (Richardson, 1992) the author has tried to study that mnemonics imagery can be helpful in treating the patients whose brain got damaged due to some injury or ailment. Clinical research has proved that usage of mnemonic imagery has helped a few patients whose memory suffered due to brain damage. The usage of Mnemonic imagery has shown improvement in few cases but it varied from patient to patient. Those with severe damage did not demonstrate any improvement.

In a study by Gibson (2009) a teaching pattern and curriculum was designed to teach nursing students. A mnemonic based framework based on acronyms and visualization was prepared for the nursing students to help them understand the course.

The article by Katre (2004)presents the usage of mnemonics techniques as the tools of a pictorial interface for self- identification of illiterate villagers. The study relied on the villagers' existing visual literacy. In order to learn and use the second language, the learners used different strategies.

The article by Macaro (2006) reviews the problems related to strategy research and proposes a revised theoretical framework in which strategies are differentiated from skills, processes, and styles. The article also proposes a series of features essential to describe a strategy so that better and doable results can be achieved.

In an article by Beitz (1997)like other researchers and scholars, the authors feel that incorporating appropriate mnemonics at the correct time and in the correct manner enhance the learning level of the students. In a study by Wolgemuth et al. (2008), the relationship of mnemonic strategies and academic performance of secondary school age students with disabilities was explored. The finding of this review supports that inclusion of mnemonics in study methods and teaching methodology does bring improvement in students' academic performance.

Cawley et al. (1979) find which is based on the information collected from the literature as well as an extensive data by the authors, includes an interpretative review of the characteristics of learning disabled youth as they relate it to mathematics. The authors delineate the established many facets of failure which the learning disabled youngster is facing in day to day life. A set of discriminators were specified for identification of certain subgroups of learning disabilities. Finally, the data presented were shown to provide insight into assessment procedures for youth with disabilities in mathematics. The focus was on problem-solving competence and the application of mathematical skills and concepts to "real-life" situations.

The study (Allinder, 1996) explored that, the effect of differential implementation of curriculum-based measurement (CBM) on math computation achievement of students with mild disabilities. The selected variables associated with the quality with which teachers implement CBM were examined. The group of twenty-nine special education teachers; each monitored two students with mild disabilities in math computation using CBM for 16 weeks. The Results indicated that students whose teachers implemented CBM more accurately made significantly greater math gains than it did on students, whose teachers (a) implemented CBM less accurately and (b) did not use CBM. Adequacy of planning time was associated with the quality of CBM implementation. It is noteworthy to understand that devising a methodology for implementation eloquently serves the purpose of the gradual learning process.

Anastasi (1988) explored the psychometric testing methods and suitability of the respective methods and its usage among learners. Part 1 of the work deals with test origins, characteristics, uses, norms, reliability, validity, and item analysis. In the discussion part of the specific tests in Parts 3, and 4, the application of the principles presented in Part 1 is repeatedly used and various statistical concepts employed in the text have been explained and illustrated.

In the research paper written by Bana & Korbosky (1995) on Children's knowledge and understanding, basic mathematical facts at primary school level reveal that recalling/retention of these mathematical facts is a challenge. However, same deductions after reaching adulthood may happen due to lack of interest in that subject. It is always noticed that facts and figures which are of no interest among learners are forgotten.

Earlier, Strang & Rourke (1983) studied the Category Test performances of two groups of children who performed at the same impaired level in mechanical arithmetic, but some of them exhibited quite different patterns of performance on academic and neuropsychological measures which were compared. The significant differences between the two groups on the Category Test were interpreted in the light of the different patterns of neuropsychological abilities and deficits of these two groups. Some socio-emotional and remedial ramifications of the pattern were exhibited by the group.

Another research study by (Batchelor et al., 1990) highlighted that efficacy of a cognitive-based arithmetic problem-solving model was tested using 989 students with learning disabilities. The Comprehensive neuropsychological test battery information was used to predict composite arithmetic test performance as a means of examining the utility of this model. Results of this study offer support-said-model in accounting for arithmetic performance under continuous visual stimulus conditions. However, these data indicate a more complex neuropsychological underpinning to arithmetic performance in both visual and aural stimulus conditions. The neuropsychological aspects of arithmetic problem solving were discussed in relations to this cognitive-based model.

In the works (Higbee, 1985) and (Higbee, 1987) the author focussed on Process Mnemonics (PM) and formulated its Principles, prospects and discussed relevant problems and tried to understand the cross-cultural impact of *Yodai Mnemonics* in education. He claimed that all research on mnemonics has been majorly published in the United States, Canada, and Great Britain. He considered a Japanese educator, MasachikaNakane, who developed mnemonics called *Yodai* (meaning "the essence of structure") for teaching mathematics, science, spelling, grammar, and English. Whereas most mnemonics help one to remember specific facts but this helps one to remember principles, rules, and procedures. Hence, Yodai mnemonics have been adapted for teaching mathematical operations with fractions in the United States. Higbee (1987) describes this mnemonics and reviews research on their effectiveness in instruction and usability. Research questions can be framed on the nature of Yodai and on adapting Yodai in Western cultures are broadly highlighted for further research. Maier (1980) notes that the failures of typical problems taught in school and some suggested remedies were featured. The specific analysis needs to be strengthened.

The use of Keywords as mnemonic highlighted by Mastropieri (1988) has shown that a variety of methods are effective for assisting students in learning the meanings of new words. It is important to note the work (Stahl & Fairbanks, 1986) in this context. Few more studies were done by (Levin et al. 1984), (Mastropieri et al. 1985), (Pressley et al. 1983), (Scruggs et al. 1985) and they have found the keyword method given by (Atkinson, 1975) is superior for teaching meanings of new vocabulary words. The Keyword method is a mnemonic technique to increase initial learning and retention of facts. This method also relies on strong upon visual imagery as this method is found fairly useful among handicapped learners (McLoone et al. 1986). In the process, we do recoding of the facts as per the system of facts given in the texts.

2.2. Assessment Objectives

In order to examine and assess the effectiveness of the Mnemonics, well-planned sessions were conducted by the facilitators to fulfill defined learning outcomes [Exhibit 1]. These objectives fulfill the scope of this research in relation to measure the multi-disciplinary learning capability.

Exhibit 1: Learning Outcomes

S. No.	Subjects	Learning Outcomes
EL01	English	Helping Students to memorize vocabulary
EL02	English	Memorizing words using memory palace technique
ML01	Maths	Learning of numerical computations using image mnemonics
ML02	Maths	Learning of Derivatives, Integration and Divergence using visual mnemonics

Mixed Research Methodology has been used to carry out this research. Both primary and secondary methods of research have been used to attain optimum and concrete results. In order to examine and assess the effectiveness of the Mnemonics, well-planned sessions were conducted by the facilitators. Sixteen Bachelor of Technology, first-year students were trained to use different Mnemonics especially in the context of two subjects: Language (English) and Mathematics. Each session lasted for 30 minutes. Total 20 sessions were taken by the facilitators to train the students. The facilitators made an endeavor to analyze the learning capability of Mnemonics as a teaching pedagogy in two subjects: English and Mathematical Concepts. The primary objectives of the sessions were: to make the students familiar with the usage of different Mnemonics, understanding these Mnemonics usage and to observe whether they increase the proficiency in crossdisciplinary subjects like English and Mathematical Computation. Two assessments were taken in each subject which we have defined as, Pre-Training and Post-Training tests. Preassessment was taken before the training of Mnemonics and the final assessment was taken after the students were trained in different Mnemonics. In order to obtain accurate results, the students were not informed in advance about their final assessment to keep the randomness in data collection. They were informed just an hour before their assessment.

Different Mnemonics were used to teach both subjects. To improvise vocabulary, Memory Palace technique was used so that the memorization of words can become easier for the students. Generally, it is observed that students follow rote learning to prepare their theoretical exams. They somehow manage or use rote memory to memorize the relevant material for their exams and quizzes but they fail to retain that memorized material for a longer period of time. Just a brief introduction of mnemonics was given in the first session. In the samesession a text was given to the students. Some words were highlighted in the text. A few extra words were also written below the text. The students were told to memorize those words. They were also told that random assessment would be conducted and they would be asked to write those words. After a week the students were told to recall and write the words they had learned from the text. The assessment was conducted and the results were recorded.

The introduction of Memory Palace was given in the second session. The students were apprised of how the technique was used by the Greeks and Romans to memorize things. They were also told that earlier the technique was called The Method of Loci. To begin the training a picture of a big hall was taken. That picture had furniture, floor mats, lampshades, etc. The picture was shown to the students and they were asked to memorize the minute details of the picture. Two sessions were devoted to this. Each and every student had to memorize the picture in such a manner that they could easily visualize each and every object placed in that room and could make a smooth and effortless memory walk to that hall. Since all sixteen students were to be trained in Memory Palace in a limited time, one common picture was finalized and used as Memory Palace by the facilitator. The students were also told that in future they can choose any place which is familiar to them and make their memory palace.

Through the Memory Palace Technique, the students were helped to memorize the names of Twenty-five world's largest rivers. Once the students had memorized the picture the facilitator associated all twenty-five rivers with twenty five different objects in that picture. Later that picture was shown to the students. The students could see that with each object a name of the river was attached. They were later asked to memorize the names of the rivers attached with the objects. Since they had already memorized the picture it took them less time to memorize the names of the rivers. Another few sessions were devoted on this exercise. It was ensured that each and every student had memorized the names of the rivers to their objects. They were asked to close their eyes and visit the hall where they could see the names of the rivers attached to the objects. Once this was accomplished the students were advised to follow this technique on their own to memorize other things of different subjects [refer to Appendix A, A.1].

The method used for mathematical computations was Visual or Image Mnemonics. The students were trained using visual techniques to compute numbers unlike traditional computation techniques used by general university students. However, subjective confusion can be seen in one visual mnemonic which was used for learning trigonometric tables. For this example, we assume that an equilateral triangle has a side *a* – the trigonometric values for $\sin 30^0$, $\sin 60^0$, $\cos 30^0$, $\cos 60^0$, $\tan 30^0$, $\tan 60^0$, etc. can be calculated applying properties of equilateral triangle rather forming an image showing these features. Similarly, we can use isosceles right angle triangle with two equal sides be *a* – the corresponding values for $45^0, 90^0, 0^0$, etc. can be calculated using the geometry and basic properties of the right angle triangle. The mathematical approach is more compact and easy to apply. Ultimately we construct the visual mnemonic which can be calculated without memorising the visual picture. This confusion can be ignored and was tackled by providing them easier visual techniques. We used visual mnemonic methods enabling them to compute, divergence, basic differentiation and integration, Trigonometric Mnemonic, Visual Multiplication by 11 (e.g. 25 X 11, 23415 X 11, 19768421 X 11, etc.) and fast squaring of numbers ending 5 (e.g. 25, 35, 195, etc.) [refer Appendix A, A.2].

After a week the students were called to give their final assessment randomly. The usage of mobile was prohibited. They were given 12 minutes to write the names of the objects on one side and the names of the rivers on the other side. The post-training assessment for mathematics was conducted for 15 questions for time duration of 5 minutes. These questions were based on their high learning capability or fast computation capability without using traditional methods to calculate. The students completed their test on time. Some of them could complete before time. The results of those tests are discussed in the section 5. In the next section we have explained the statistical methods used for the research.

3. STATISTICAL ANALYSIS & RESULTS

The item analysis is an important statistical tool to determine the level of test outcomes (Yuan et al. 2012). If an item is too easy or too difficult and failing to show the difference between trained students or scores are not properly scored we find this method insightful. The statistical objective is to obtain inferences.

3.1. Difficulty Index

The 'difficulty index' is a very powerful tool which is frequently used by researchers in similar calculations (Crocker & Algina, 1986). The difficulty index is given in (Bakhoff et al. 2000) suggests that the difficulty index of an item is a proportion of students who answer a test time correctly. The higher is the proportion means, the lower is the difficulty level. Hence, the lower is the proportion means higher is the difficulty level (Wood, 1960). The formula for calculating this index is given by,

$$p_i = \frac{A_i}{N_i} \tag{1}$$

In equation (1), $p_i =$ difficulty index of item *i*, $A_i =$ Number of correct answers for item *i*, $N_i =$Number of correct answers and plus number of incorrect answers for item *i*. The Subjective questions are essay type in nature so, the formula can be broadly written as:

$$P = \frac{\bar{X}}{R} \tag{2}$$

In equation (2), P = Difficulty Index, $\bar{X} =$ Average Marks, R = Range of Marks (Maximum Marks allocated – Minimum Marks allocated).

3.2. Hypothesis Testing

We assume that; the final tests measure the ability or competence of students after training so, we can deduce that for the distribution, $N(\bar{x}, s)$which has high mean scores, shows a good use of the mnemonic method accurately after training. It is important to measure the proportion of examinees who answered the item correctly in the 'satisfactory zone' or passing marks determined sufficiently by, *p-value* corresponding to the test-statistic. The normal range is between 0.0 and 1.0, with a higher value closer to 1 suggesting that item was easier to obtain passing grade. For our training tests referred as CRTs (Criterion-Referenced Tests) where the central idea is to test mastery over method's usage for faster calculation or remembering a list of facts, the p-value assumed to be higher closer to 0.9. The sample size for our evaluation is less than 30, i.e., $n = 16$ so, this follows t-distribution with $(n-1) = (16-1) = 15$ degrees of freedom. Thus, the formula for calculating $t*$ (t-statistic) is given by:

$$t^* = \frac{\bar{x}-\mu}{s/\sqrt{n}}, s = \sqrt{\frac{\sum(x-\bar{x})^2}{n}} \quad (3)$$

Where, $\bar{x} =$ Sample data mean, $\mu =$ Assumed mean for null hypothesis, $s =$ Standard deviation of the sample, $n =$ sample size. The values are calculated on justified assumed null hypothesis for our purpose and presented in the results section. Also, suppose we set our significance level α at 0.05, so that we have only a 5% chance of making a Type I error. The table of descriptive statistics calculated is shown in Exhibit 2 [see next]. In Exhibit 2: E1 = Pre-training Exam (English), E2 = Post-training Exam (English), E3 = Pre-training Exam (Maths), E4 = Post-training Exam (Maths). This summary statistics is calculated from E1, E2, E3, E4 [refer Appendix B].

Exhibit 2: Descriptive Statistics

Test Subjects	Difficulty Index (P)	Sample Mean ($\bar{X}$)	Standard Deviation (s)	Test Statistic	Critical Values
E1	0.10661	3.625	-	-	-
E2	0.550625	13.76562	6.46652824	-0.7635503	0.228648
E3	0.91666	5.5	-	-	-
E4	0.45	6.5	4.10030	-2.4388	0.013843

4. DISCUSSIONS OF RESULTS

From the Exhibit 2, we see that difficulty index for pre-training results (E1 \& E2) for English was low thus, the question paper had higher difficulty level [refer A.3 of Appendix A which contains pre and post-training score of students]. This can be translated into the capability to write correct answer, which is low for pre-training test for English. At the same time, post-training test difficulty index is higher than 0.5 shows that the question paper was solved easily by the students thus, showing higher capability. Similarly, for pre-training test for Maths, the difficulty index was 0.91, which shows the question paper was easy for them. Thus, shows a high level of solving capability. The difficulty index for the post training test for Maths was 0.45 which says that question paper was not so easy. Thus, shows a low learning capability of the fast calculation methods which was trained to them using visual mnemonics. We therefore, used hypothesis testing to discuss the variability of the capabilities measured through assumed means and sample means [sample mean for English = μ_e, the sample for maths = μ_m]. The student-t distributions for post training results are shown in Figure 1.

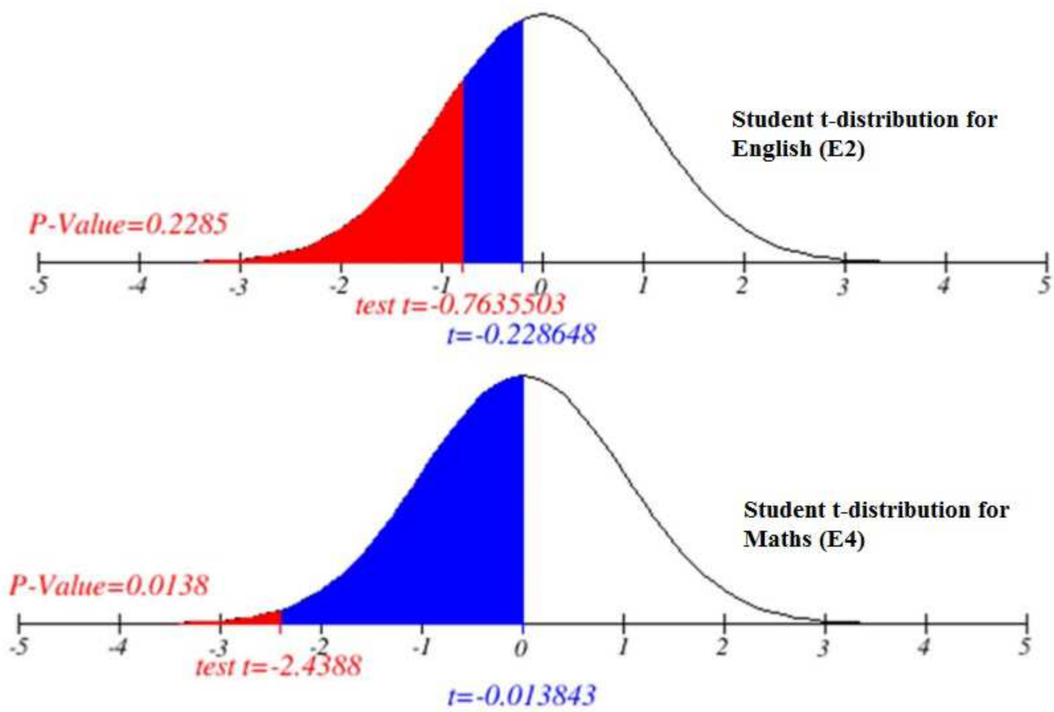

Figure 1: Student T-Distribution

4.1 For test - E2: The p-value (critical value) for left-tailed test at 15 degrees of freedom is derived at, $-t^{*}_{0.05}$ is 0.228648, which comes in rejection region i.e. $(-\infty, -0.228648]$. Thus, we reject null hypothesis $H_0 : \mu_e = 15$and accept the alternate hypothesis, $H_a : \mu_e \leq 15$ at 5 percent Chance of making Type I error. This suggest that a lower sample mean than 15 shows a good level of learning. In our case, this helps to understand that post-training results sufficiently suggests that a good level of learning happened with regard to the marks obtained.

4.2 For test - E4: The p-value (critical value) for left-tailed test at 15 degrees of freedom is derived at $-t^{*}_{0.05}$ is 0.013843, Thus, we do not reject the null hypothesis $H_0 \colon \mu_m = 9$ and so, it corresponds with the mean assumption was correct with regards to the students post-training test results. Hence, we can say that learning level was not high among students using the method as the mean score of 9 is applicable.

5. CONCLUSIONS

From our research we conclude that, the learning level can be improved from the usage of mnemonics in rote memory based subjects such as, English Vocabulary, List of Facts etc. However, this opinion differs in mathematical subjects like, computations, calculus etc. The adaptability of Image Mnemonics method in mathematics is confusing for the random sample of technical degree students. It is important to note that the coinciding features of image mnemonics in mathematics creates a confusion that, whether the method is a mathematical concept or a mnemonic method. There is a plenty of scope for further research in this area. We are suggesting a few topics which are falling under this scope. How teaching pedagogy can be refined using mnemonics in rote memory-based learning and concept-based learning? In some engineering courses (Computer Science, Electronics, Electrical, Mechanical Engineering, etc.) where the positive learning outcomes are based on the memory based learning as well as mathematical concepts based learning; How the experimental results based learning and the mathematical concept based learning be tackled? And what will be teaching pedagogy to adopt this? How can one ascertain the adaptability of the mnemonic method whether it is high or low in these technical courses? In this paper we observed that it was low for mathematics. A subjective comparison can be a breakthrough to study the topic in greater detail.

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APPENDIX A

A.1 Material Used for E1 & E2

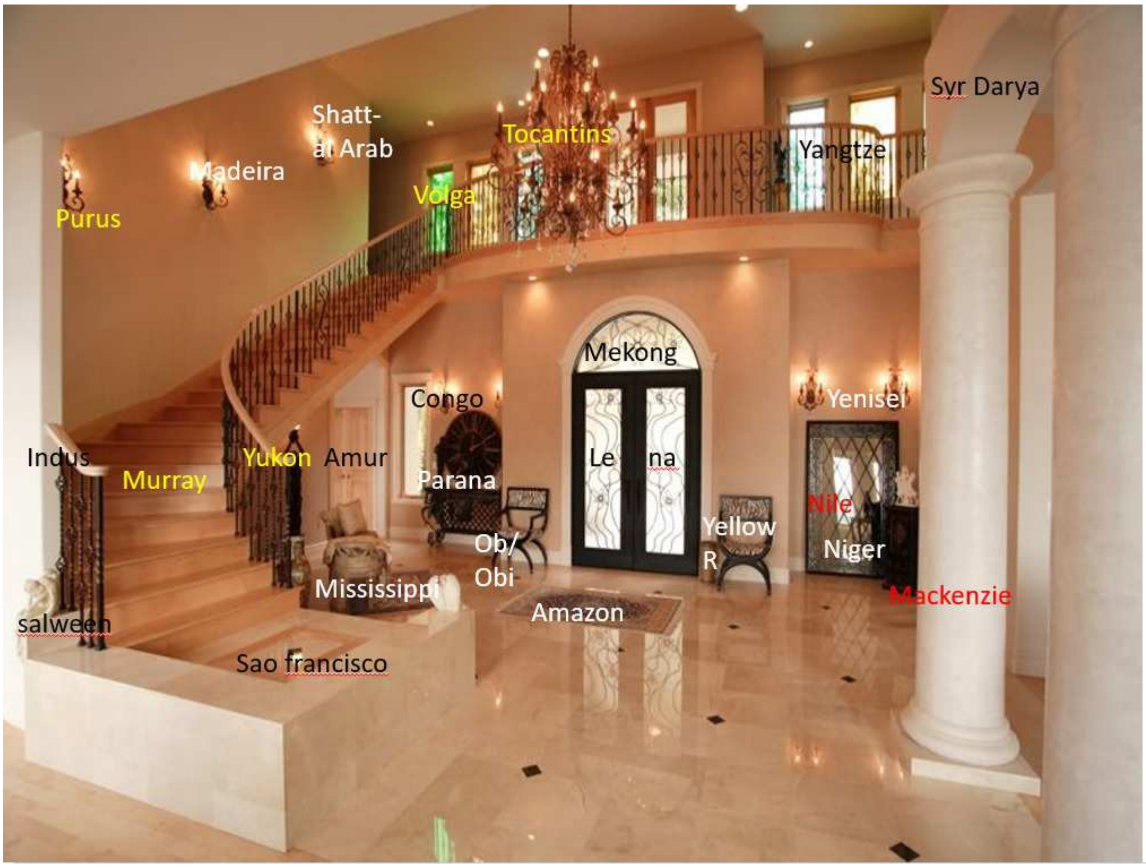

Figure 2

A.2 Materials Used for Maths (E3 & E4)

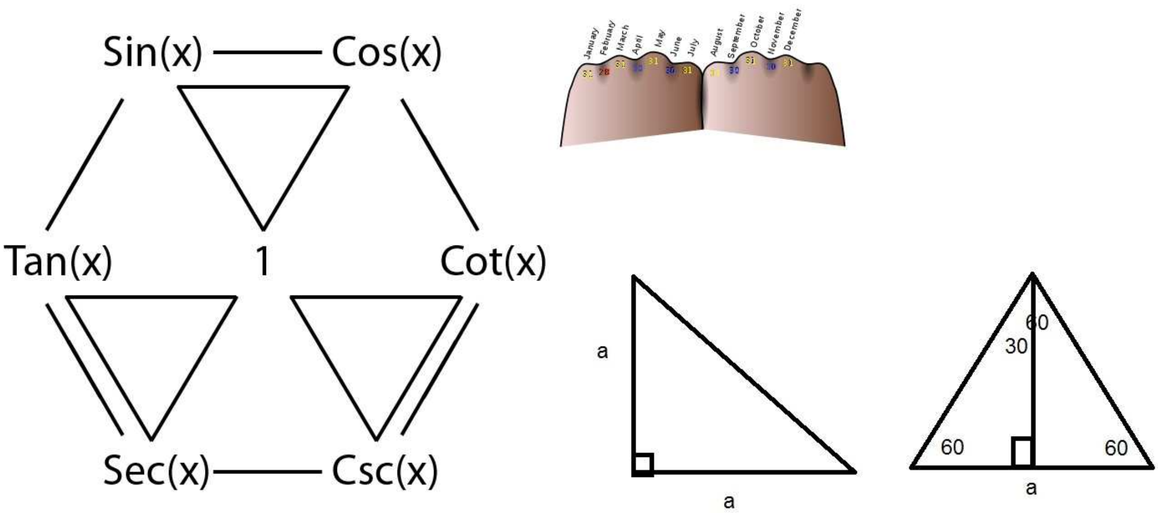

Figure 3: Training Material 1

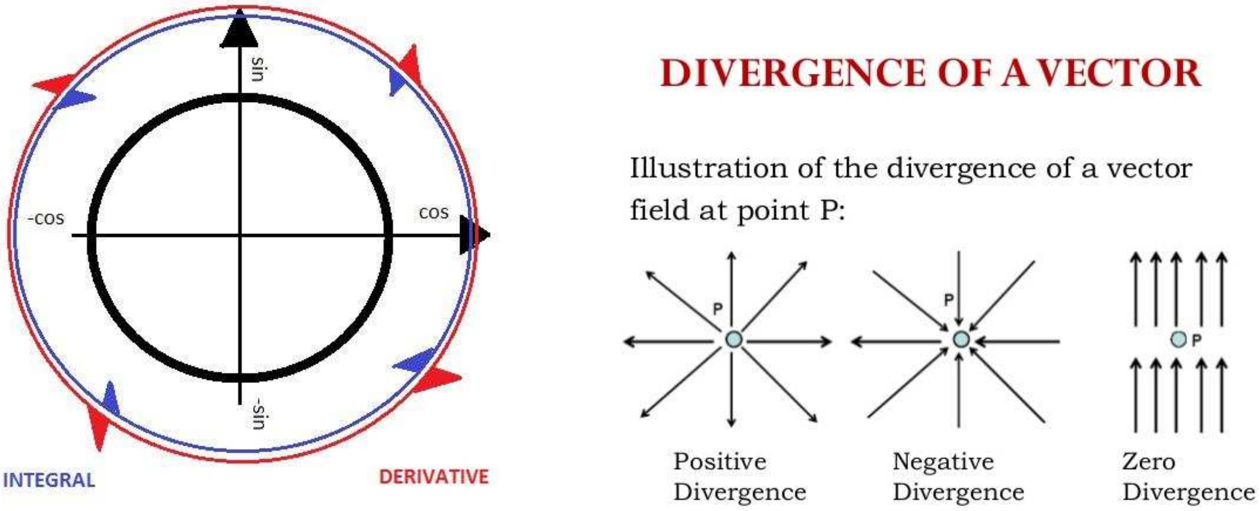

Figure 4: Training Material 2

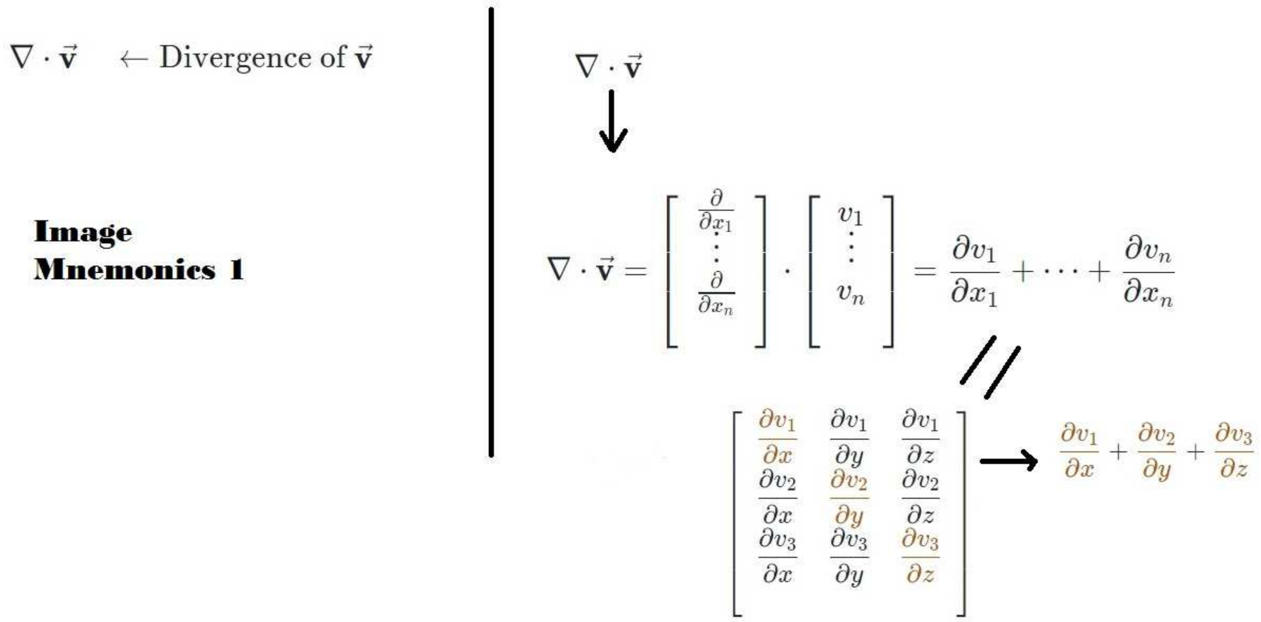

Figure 5: Training Material 3

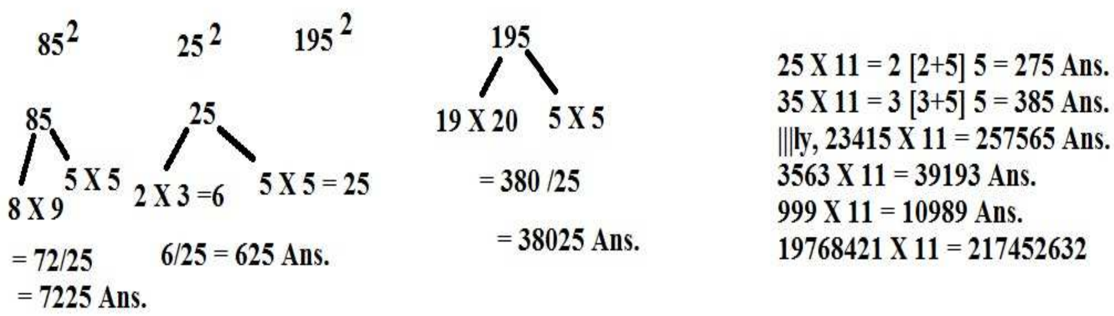

Figure 6: Training Material 4

APPENDIX B:

Marks Obtained by Students in Exams (E1, E2, E3 & E4)

Pre-training Scores for E1

Students	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Marks	6	2	1	5	8	10	4	1	1	1	0	3	5	0	1	10

Post-training Scores for E3

Students	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Marks	18	7.5	12.5	6	21.25	15.75	19	20.5	15	11.5	3	8.5	18	1.75	21	21

Pre-training test Scores for E2

Students	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Marks	5	6	5	5	5	6	4	6	6	6	6	5	5	6	6	6

Post-training test Scores for E4

Students	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Marks	6	5	6	5	8	12	9	8	10	0	7	5	1	11	11	4

Figure 7