DOI PREFIX 10.22183
JOURNAL DOI 10.22183/RN
SIF 7.399

RESEARCH NEBULA
An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Arts, Commerce, Education & Social Sciences

ISSN 2277-8071

MANAGING COGNITIVE LOAD USING MULTIMEDIA IN HIGHER EDUCATION

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Received: 10.05.2024 Reviewed :14.05.2024 Accepted: 16.05.2024

ABSTRACT

Higher education in India is not a new phenomenon in Indian history. The need and importance of higher education changes according to the changes in time. On the basis of the current demand, NEP-2020 recommended optimal learning environment and learner support for providing qualitative higher education. Now a days managing cognitive load using multimedia is considered as an important aspect of creating an efficient learning environment. Cognitive load refers to demands for working memory resource to process information during a specific task. As the working memory has very limited storage, it is being overloaded while learners try to learn any new concept. Due to this overloading of working memory the learning efficiency of learners decreases. Now a days multimedia is believed to enhance brain's ability to make effective connection between verbal and visual representation of content that facilitates learner engaged learning which leads to in-depth cognitive processes and results in managing cognitive load among higher education learners. Therefore, the author intends to explain in this paper - the concept of managing cognitive load by using multimedia in teaching and learning process which creates an efficient learning environment and provides ample learning experiences to the learners. This leads to increase qualitative improvement in higher education.

KEY WORDS: *Multimedia, Cognitive load, Higher education*

1. Introduction

Higher education in India has a long history. Higher education in ancient India was based on religious and Vedic education which covers a vast range of subject like astrology, surgery and medicine, agriculture, architect, mathematics, literature. A large number of higher educational institutions like Nalanda, Takshashila , Puspagiri, Valabhi were established in Vedic period. These higher education institutes attracted scholars from all over the world. From Vedic period to this 21st centuary Indian higher education has seen significant changes. Today Indian Higher Education System is one of the largest education systems in the world.

This era of modernisation and globalisation have brought a drastic change in Education. It is focused on competency based higher education as it is the most significant input for growth and development of the country. It changes human beings to human resources. It is impossible to build a sustainable nation without human resource development, which mainly depends on the quality of higher education of a nation. Since the last one-decade Indian higher education has improved significantly but despite its

impressive growth, it is unable to give competency or skill based higher education. So, it is difficult for learners to apply those learned skills in new situation and leads to increase in unemployment.

In this emerging scenario, there are lots of issues and challenges faced by Indian higher education. These comprise poor quality of teaching, insufficient fund for higher education, teachers focused on theories rather than practical aspect of concepts, traditional methods of classroom transaction, poor infrastructure. Poor quality of teaching generally depends on numbers of factors like poor teaching strategies, untrained teacher, traditional method of teaching, rigid curriculum, in appropriate presentation of learning resources, and weak instructional design. This increase psychological stress, frustration, demotivation, increase anxiety, and randomly making mistakes among students of higher education. All these psychological problems decrease quality of their judgement, productivity and sometime their brain also stops working.

NEP-2020 recommends an optimal learning environment and appropriate support for students. An efficient learning environment involves relevant curriculum, students centred pedagogy, continuous and comprehensive assessment. The curriculum must be according to the need and interest of students, updated in proper interval for the latest knowledge. Engaging pedagogy deals with successful imparting of knowledge with appropriate learning instruction and assessment methods. Continuous student support includes continuous positive feedback of teachers and motivating.

An effective instructional environment results in faster and better learning outcomes. It expects the teachers to have an understanding of human cognitive system and cognitive processing, since learner's cognitive abilities is the base of his learning outcomes.

2. Human cognitive system

Human cognitive system is the most complex information processing system. It has the biggest store of organised information with unlimited storage capacity for a long time. This system generally deals with three types of memory i.e., long term memory, short term, and working memory. Long term memory is the store house of information and our previous experience. Here the knowledge structures are stored in the form of schema. In our daily life we use knowledge structures or previously existing schema of long-term memory for bathing, cycling, eating, or responding to any social situation. By using long term memory, we can learn new concepts, solve problem and these leads to increase our knowledge structure or schema. If nothing has reformed in our pre-existing schema, then there is zero transfer of learning. Some time we are not able to respond or do any social situation or activities due to the lack of existing schema. So long term memory has a vital role in learning new concepts.

Till now the concept of short-term memory is in controversy. It allows the information to retain for a very short span i.e., 15-30 seconds. After that we are not able to recall or process this information. According to George Millar (1956) Short term memory is able to hold only 7+_2 items of information at once. But recent studies suggested that we can hold four chunks of information simultaneously in short term memory. By practice and mental rehearsal, we can move new information to long term memory. According Atkinson and Shiffrin's (1968) model of memory structure, short term memory is sub divided into temporary store and control processing. This was changed later by Baddeley and Hitch (1974) and is known as working memory and help in processing and retrieval of information in long term memory.

According to working memory of Baddeley (2000), it is a temporary storage system under attention control and underpins our capacity for higher order thinking. So, it deals with temporary storage and the task we do at that instant. This also direct our attention wherever necessary and increase our mental capacity for higher order thinking. Working

memory system has generally 4 components and they are-

(i) Central executive: -
direct working memory resources to achieve the determined goal

(ii) Phonological loop: -
hold information which is speech-based

(iii) Visuo-spatial sketchpad: -
hold information which is visual and spatial

(iv) Episodic buffer: -
binds all information together from different sources

Working memory is active in nature and involved in processing of complex task or task we are doing right now.

Some time we feel overloaded while trying to learn something new. For example, if a person wants to learn to drive a car, here at starting he has to hold lots of information simultaneously in his working memory which he feels very difficult. This is occurring due to the overload of working memory as it has a very limited storage capacity. Due to this overloading of working memory, our learning efficiency decreases or if the overload of working memory increases it tends to stop the learning process. At this time due to too much of information processing simultaneously the limit of our working memory exceeds and leads to cognitive overload.

3. Cognitive load

Cognitive load has various dimensions representing the task enforces on the learner's cognitive system during the performance. A number of characteristics like difficulty of task, interrelationship between the elements of task, mode and pace of learning instruction, learning resources used, psychological pressure, age, previous knowledge of learner, and ability of learner influence the cognitive load. Cognitive load is the cognitive resource or working memory resources demand for processing the information by a specific individual in a specific task. Thus it is the theoretical concept which reflect the interrelation between the information structure and learner cognitive abilities. Cognitive load is directly related to the working memory processing. So, it is the conscious processing of working memory that occurs during processing a task.

3.1 Types of cognitive load

All forms of cognitive loads are not useful and some are waste mental resource. Here our goal in teaching learning process is to lessen the irrelevant forms of load and increase the necessary forms. There are generally three forms of cognitive load i.e. (i)Intrinsic load, (ii)Extraneous cognitive load, (iii)Germane cognitive load. Since we have limited mental resource, we have to manage these three loads.

3.1.1 Intrinsic cognitive load

It is related with the complexity of the content material or mental effort forced by the difficulty of the content material. The extent of intrinsic load can be determined by the element interactivity of the content. Example: - understanding the whole concept of periodic table is difficult as compared to its individual elements. Because that concept of whole periodic table involves higher element interactivity. Here higher element interactivity means the task accomplished in a coordinated fashion rather than serial way so it demands more cognitive resources. The quantity of intrinsic load depends up on the experience or amount of long-term memory of the person in that specific field. In expert learner the element interactivity is low as compared to the new for the same task, as experts have the schema relevant to that task in their long-term memory. As an instructor we cannot directly alter the inherent cognitive load as it is related to knowledge and skills associated with our learning objectives but we can manage it by using various strategies. Some time it is important to increase the intrinsic load rather than minimize it because if the learning task has very low element interactivity, then it is easy for the expert learner and very little cognitive resource use and learning may be very less. Here we can use various techniques to increase essential load. Therefore, the amount of intrinsic cognitive load is determined by the degree of interactivity between individual tasks and

experience of students in that definite field. As this load is essential for learner to achieve learning object it is also considered as essential cognitive load.

3.1.2 Extraneous cognitive load

This load is the opposite of intrinsic cognitive load. It is irrelevant to our learning goals and generally unproductive and non-constructive in nature. Extraneous cognitive load is produced by the cognitive activities involved by the external design related to the task or learning material like poor instructional design, poor use of multimedia, or inappropriate use of various learning modes. For example, when we use two mutually depended learning resources separated by physical distance or time, it demands for more working memory to integrate both resources. As a result, it leads to running out of our cognitive resources unnecessarily and there will be deprivation of cognitive resources for important cognitive processing. In this condition the cognitive resources demand is irrelevant for our learning goal so they are considered as irrelevant or unnecessary cognitive load. Both extraneous and intrinsic cognitive load results total cognitive load. We always have to consider that the total cognitive load should not surpass the limited working memory of the student which varies according to his expertise in respective domain. In case of learning a task with low element interactivity the total load cannot surpass the working memory capacity and the extraneous cognitive load does not have any impact on the learning outcomes. But in higher element interactivity task, the total cognitive load exceeds due to the high level of intrinsic cognitive load. In this situation irrelevant load already used the cognitive resources and there is insufficient cognitive resource for essential cognitive activities. Here if after eliminating irrelevant cognitive load, and total load exceed the limited capacity of working memory, then it will be a challenging situation for instructors to manage.

3.1.3 Germane cognitive load

It is the essential form of load which is straight related to our learning goal. This cognitive load causes due to the additional learning activities which are intentionally designed by the instructor to increase the learning outcomes. Due to this additional learning activities the total cognitive load exceeds but also contribute to the learning. In this situation first the instructor can reduce the extraneous cognitive load to get load with in the limited working memory. After this the remaining cognitive resource can be used for essential cognitive activities. Even if after first procedure the cognitive load exceeds our working memory in the second step, we can also reduce essential cognitive load, by reducing the additional learning activities which are intentionally designed. This situation occurs when the intrinsic cognitive load is very high. If the 2nd procedure is also unable to get the cognitive capacity within the limit, then we can apply various strategies to reduce intrinsic cognitive load like segmenting, and sequencing.

3.2 Importance of balancing cognitive load

Working memory capacity is the base for any learning process. Working memory permits the handling of stored information of long-term memory, we can either modified our existing schema or formulate new schema in our long-term memory, which leads to learning. So, working memory capacity is crucial for any cognitive processing as it carries out multistep direction, direct attention, and remember information. Therefore, working memory is called as the bottle neck of any learning process.

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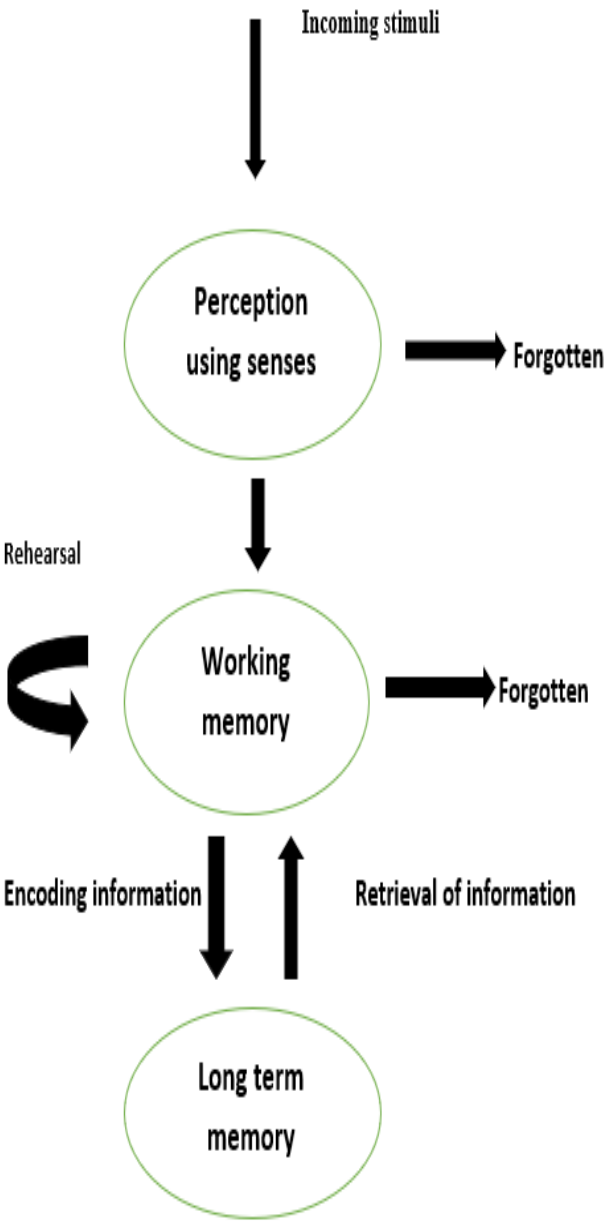

Fig.1 Process of human information processing

In the above model of information processing, it is shown that after the perception of information it is rehearsed by various strategies and the incoming new information encoded with the existing schema of long-term memory and either modified or replaced the existing schema. When an individual needs the stored information or schema present in his long term memory during processing of any cognitive activities, it can be retrieved spontaneously from long term memory. If the incoming information is not perceived or not manipulated by working memory with in the stipulated time, then it is lost. Cognitive load is related with the mindful processing of information in working memory and our working memory has limited capacity. Therefore, it is very important to manage cognitive load to optimally use our cognitive resource which leads to better learning outcomes. This managing of cognitive load is easily done by using cognitive load theory as it provides an efficient learning environment.

Cognitive load theory was developed by John Sweller in 1988.This theory is based on numbers of universally accepted theories about process of leaning and information storing in human brain. This theory provides a general instruction to the instructor or curriculum developer to create an efficient learning environment here the instructor tries to minimize the extraneous load and increase germane load. Dylan William tweeted on 26 January 2017 that cognitive load theory is the single most important things for teacher to know. In 21st century using multimedia that plays an important role in designing an effective learning environment specially in higher education. The instructor can use multimedia to manage the cognitive load in higher education to increase the learning outcomes.

4. Managing cognitive loads using multimedia in education

Learning outcome can be more qualitative if the instructor uses various multimedia learning resources in his learning environment. He can use various words, pictures, diagram, maps, audio, video, animation, interactive simulation to make his teaching learning process more effective and increases the quality in school education**.** Richard E. Mayer (2001) is a cognitive scientist who developed a frame work of using multimedia in learning which is based on three norms: -

(i) Processing of dual channels: -
Human beings have two separate channels in cognitive system of his brain for processing visual and verbal learning instructions. They can select relevant words and visuals

for processing in verbal and visual working memory respectively.

(ii)Limited capacity of channel: -

Each channel can process limited amount of information

(iii)Active processing: -

For meaningful and in-depth understanding of the learning concept, learner's cognitive system must be able to select, organize logically, and integrate the information with the pre-existing schema.

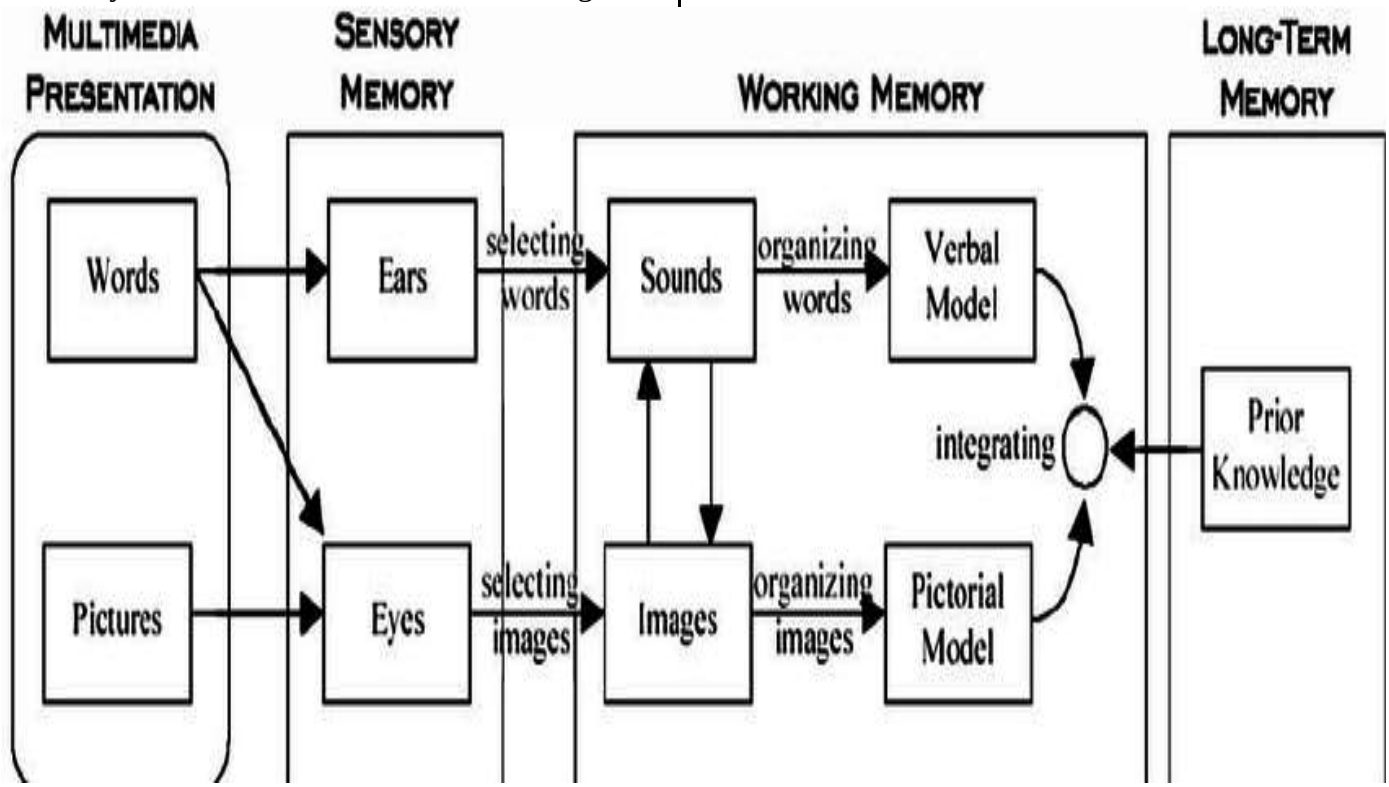

Fig.2 A Frame work for cognitive theory of multimedia learning prosed by Mayer.

4.1 Managing cognitive load using multimedia

Knowingly or unknowingly teachers do adopt irreverent pedagogy. It is harmful in case of enthusiastic teachers using over usage of teaching aids leads to cognitive load. At the same time there are teachers unaware of the science behind learning and inadequate utilisation of necessary teaching aids leads to weakening of memory. This necessitates the need for teachers to be aware of types of cognitive load and the ways and means of optimal usage of multimedia for the learners to manage cognitive load balancing. Here in the following table the author spelt out the interfering components, right usage of multimedia results in efficient learning environment that develops management of cognitive load balancing among learners.

Scaffolding for balancing cognitive load using multimedia

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Sl.no	Interfering components hindering learning process	Suggestions for rectification using multimedia	Outcome
1	Inadequacy in using visuals	• Diagram can be shown simultaneously and process sequentially	• Less effort in searching resources and quick processing of information In-depth understanding through audio-visual aids.
2	Split attention	• Taking care of inter-related learning resources alignment in same page • Utilising signal and clues • Using self-explanatory TLM	Free working memory and increase cognitive processing
3	Redundancy in content	• Using appropriate choice of aids (audio or visual) eliminate redundancy /self – explanatory	• Acceleration of cognitive processing • Increase in germane cognitive load
4	Inappropriate transaction of content	• Presenting content in small steps • Establishing logical relationship between the steps • Chunking of content into small components • Integration of all components and make meaning. • Seeking help from subject matter expert	• Comprehension of the content
5	Overlapping of information	• Focusing titles (theories, definitions, facts) separately	• Clarity in understanding the concepts
6	Ignoring individual differences	• Providing self-paced learning materials like pre-recorded videos/audios based on the need	• Student centric learning • Self-paced and meaningful learning
7	Improper guidance to access and use e-resources	• Using simulation and educational games • Providing opportunities in real life situation	• Development of abstract thinking/logical thinking and problem solving capacity • Ability to deal with social situation • Improvement in decision making
8	Negligence of practice	• Allowing rehearsal	• Schema formation in long term memory
9	Poor instructional design(cognitive load is higher in new leaner than expert learner)	• Minimizing distraction • Eliminating redundant information • Engagement in learning environment • Adopting sequencing and segmenting • Providing self-paced learning environment • Sketching out the learning goal simple and concise • Increasing higher level cognitive processing • Tuning of meaningful and deeper understanding • Automation of learner skills	• Learning environment becomes efficient that leads to better and faster learning • Providing ample learning opportunities to learn new things

All the above factors lead to an efficient learning environment which leads to better and faster learning in higher education. This learning environment also provide ample learning opportunities for the learner to learn new things.

8. Conclusion

To achieve the goal of NEP-2020 of providing qualitative higher education by providing optimal learning environment and learner support an efficient learning environment is necessary. It can be created by managing cognitive load using multimedia in higher education. Therefore, an efficient learning environment act as medium for qualitative learning outcome. But now due to the lack of training and awareness the educational planners and instructors are not able to create efficient learning environment. Therefore, it must be recommended for introducing the concept of cognitive load management using various multimedia in the curriculum of pre-service and in-service training program, orientation program and faculty development program at all levels to create awareness among the instructors, educational planners and other stake holders of education system in India. If the learner community is trained in the above liens, encountering 21st century challenges will be manageable.

References: -

1. Baddely, A. D. (2000). The Episodic Buffer: A New Component of Working Memory? *Trends in cognitive sciences*,4(11),417-423.
2. Solanki, P. P. (2019). Education In India: Emerging Issues, Challenges. *Open access journal of interdisciplinary studies* ,2(3),202-207.
3. Hiwarkar, A ., Nirbhavane, S. & Rawat, P. (2016). Higher Education In India : Present Status And Path ahead. *International Journal in Management And Social Science* ,4(6),441-456.
4. Mayer, R. E. (2ND Ed). (2005). Cambridge Hand Book Of Multimedia Learning . Network :Cambridge University Press. USA.
5. Kalyuga, S. (2009). Managing Cognitive Load In Adaptive Multimedia Learning. *Information and Science reference*. United states of America.
6. Kalyuga, S. (2009). Cognitive Loads Factors in Instructional Designs for Advanced Learner. *Nova Science Publication. lnc*. New York.
7. Clerk, C .R., Nguyen, F. & Sweller, J. (2006). Efficiency in Learning: - Evidence Bases Guidelines to Manage Cognitive Load. *Preiffer A Wiley Imprint*.San Francisco.
8. Sweller, J., Ayres, P. & Kalyuga, S. (2011). Cognitive Load Theory. *Springer Publication*. New York.
9. Ayres, P. (2006). Impact Of Reducing Intrinsic Cognitive Load On Learning In A Mathematical Domain. *Applied Cognitive Psychology*,20,287-298.
10. National Education Policy. (2020). Ministry Of Human Resource Development. Government Of India.
11. https://www.inspiritive.com.au/human-cognitive-architecture-cognitive-load-theory/#:~:text=Human%20cognitive%20architecture%20describes%20the,a%20system%20for%20processing%20information
12. https://images.app.goo.gl/5CfPB2856vHcXP7M8
13. www.eric.com
14. Www.springer.com
15. Www.eslevia.com