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Research Paper

Cross-Domain Brain Activation in Learning: A Neuroscientific Study of an Extramural Combination of Co-Scholastic Competencies to Enhancing Educational Quality and Inclusivity in Rural Public Schools of Vikarabad District of Telangana State

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ABSTRACT

Alignment of pedagogy with how the brain learns best, integrating technology and creativity through co-curricular and extra-curricular experiences, is essential to enhance the quality of teaching-learning and this research needs priority. This is all the more important and urgent in developing countries, where a learning crisis is prevalent. The present research study examines the efficacy of a 45-hour micro co-scholastic competencies enhancement training, carried out in 10 rural public schools of Vikarabad District, Telangana State, India. Findings indicate that co-scholastic education imparted through training in these schools with standard approaches to Experiential Learning applying Art-integration and Multilingualism increases learners' interest, motivation, participation in learning and achieves higher scores in parameters of co-scholastic competencies and also in curricular topics. An attempt has also been made to map the curricular, co-curricular and extra-curricular fields under scholastic and co-scholastic areas. A probable sequencing mechanism occurring in the brain during the learning process of extracurricular activities, such as those involving art and music, applying multilingual activities, has also been proposed.

Keywords: *Learning Crisis, Learning Outcomes, Experiential Learning, Brain processing, Scholastic and co-scholastic competencies*

The current landscape of education is rapidly evolving, shaped by advances in neuroscience, technology, globalisation and the diverse needs of learners. Research in teaching–learning processes is essential to bridge gaps between pedagogy and the way the human brain actually learns in order to achieve learning outcomes.

Emerging studies in co-curricular with multilingual exposures are shown to strengthen neural networks, improving memory retention and adaptability. To respond to these insights, teaching strategies must shift towards student-centred, experiential, and inquiry-based approaches, supported by technology, continuous assessment and interdisciplinary instruction.

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Improvement and research in teaching - learning processes are thus needed as a review of the past experiences and as a guide for the enhancement of learning outcomes in the future. By continuously refining methods and grounding them in scientific evidence, education systems can remain responsive to the challenges and opportunities of the 21st century.

Background Knowledge

Reports published by the Ministry of Education, Govt. Of India[1] (National Achievement Survey (NAS, 2021) brings out the shortcomings in learning outcomes in different states of India, starting from primary to high schools, indicating the prevalence of 'learning crisis' despite allocation of funds, infrastructural facilities, and adopting favorable policies for Inclusive education, which vouches for creating a supportive environment for all children, regardless of their physical, intellectual, social, emotional, linguistic, or other conditions, to learn together.

The present data depicts the survey on the Quality of school education in Telangana state through competency-based assessment in Language, Mathematics & Environmental studies for class 3 and 5; Language, Mathematics, Sciences & Social Science for class 8 and Modern Indian language, Mathematics, Sciences, Social Science and English for class 10. According to the survey, the LO was classified as Below Basic, Basic, Proficient and advanced, and the definitions given are:

Below Basic: At this level students are at the early stages of development with respect to the curriculum standards. They have not achieved the required knowledge and skill as per the curriculum demands.

Basic: At this level, students demonstrate a basic minimum level of knowledge and skills related to the curriculum. They have ideas and can express themselves in simple language, but lack coherence. They need guidance at various stages of learning.

Proficient: Learners at this level have acquired most of the learning outcomes and skills required by the curriculum. They can work independently with minimum supervision and have a systematic methodology to solve problems. They can communicate their ideas clearly and can also connect different ideas and create meaning with minimal guidance and supervision. Efforts are required to bring all learners to attend the professional level and above.

Advanced: Learners at this level display exceptional mastery of the learning content as prescribed by the curriculum and beyond. They are independent with high analytical, reflective and critical thinking and can connect and integrate concepts and ideas to create new knowledge/meaning and solve complex problems.

The scores obtained were classified under these 4 categories which have been presented in Table 1a, 1b, 1c, 1d.

Table 1a: Percentage of students by Performance level for Class 3 children				
	BELOW BASIC	BASIC	PROFICIENT	ADVANCED
Language	52	26	16	6
Mathematics	43	32	19	6
EVS	42	33	20	5

Table 1b: Percentage of students by Performance level for Class 5 children				
	BELOW BASIC	BASIC	PROFICIENT	ADVANCED
Language	35	41	19	4
Mathematics	49	40	10	2
EVS	54	31	13	2

Table 1c: Percentage of students by Performance level for Class 8 children				
	BELOW BASIC	BASIC	PROFICIENT	ADVANCED
Language	28	47	16	8
Mathematics	32	52	12	4
Sciences	47	37	12	4
Social Science	54	37	6	3

Table 1d: Percentage of students by Performance level for Class 10 children				
	BELOW BASIC	BASIC	PROFICIENT	ADVANCED
Mathematics	36	49	12	3
Sciences	77	17	6	1
Social Sciences	64	24	11	1
English	16	13	45	26
MIL	70	28	2	0

(Note: Decimal figures in the data set are rounded up to whole numbers and hence may not add up to 100), MIL: MODERN INDIAN LANGUAGE
Source: https://nas.gov.in/, https://www.education.gov.in/major-initiatives

The data shows that more than 70 % of the children are of Basic or Below Basic level in all the classes and subjects. It is also observed that the proficiency and advanced level decreases with increase in class. These inferences mandate an early intervention for the learning crisis management to move the school children from Basic to Advanced level.
A relatable parameter to the Learning outcome is the dropout rate in children starting from the age of 6 years.

Ministry of Health & Family Welfare, Government of India, under its National Family Health Survey (NFHS-5) 2019-21, reports that Ninety-three per cent of children in the age group of 6-17 years in Telangana attend school (94% in urban areas and 93% in rural areas). School attendance is almost universal (97%) at age 6-14 years, but drops sharply to 80 per cent at age 15-17 years.

Ministry of Statistics & Programme Implementation, Government of India, 2018, reports that Financial constraints, engagement in domestic help, engagement with economic reasons, distance of school, early marriage are some of the reasons for the low attendance and drop out, besides students not interested in studies and unable to cope with studies. More than 30% of children involved in the survey showed a lack of interest in studies; they preferred to drop out because whatever was being taught in schools barely intrigued them.
From the above facts and figures, the following points need to be pondered upon for root cause analysis and curative measures.

Although the data on school enrolment is encouraging, the attendance and dropout rates in both genders are a cause for worry. As observed, the dropout rate from middle to high school, considering the reason (lack of interest), is apparently within the control parameter and one of the prime areas for our focus.

LITERATURE SURVEY

Persistent dropout rates in developing countries have always been a major challenge for educational planners and managers. Various reasons attributed (UDISE+, 2022-23) to the dropout rate in India need special attention (Hunt, 2008; Glick & Sahn, 2010; Branson, Hofmeyr & Lam, 2014).

Reasons such as socio-economic issues in the child's life are being addressed by the policy makers, governments and the civil societies. Alternatively, the reason “not interested” mentioned by Ministry of Statistics & Programme Implementation, Government of India, 2018, needs to be delved upon by the educationists and educational planners. Many workers have been researching on making the learning interesting and motivating, especially for the middle school children (Ralph B. McNeal, Jr., 1995; McCabe et. Al, 2020), where the dropout rates have been noted to be high.

Motivating middle school students in curricular activities requires a balanced approach that connects learning with their interests, developmental needs, and sense of achievement. Setting clear, achievable goals in curricular, co-curricular and extracurricular activities, help students track progress and experience small successes, fostering intrinsic motivation (Vidyadhara Hegde S, 2018). Above all, creating a supportive and inclusive classroom environment where mistakes are seen as part of learning, encourages students to take risks, stay engaged, and develop a lifelong love for learning.

Often, the words “Curricular, Co-curricular and Extracurricular, scholastic and co-scholastic” are used casually. Traditionally, co-scholastic activities are referred to as Extra-curricular activities but with a mix of co-curricular activities, because both co-curricular and extra-curricular activities (co-scholastic) develop similar skills and competencies that promote holistic development.

Co-curricular activities directly relate to scholastic competencies since the objective is to strengthen academic learning. In contrast, extracurricular activities aim to complement scholastic performance indirectly, not directly related to academic learning, through the holistic development of learners (Nandita & Aithal, 2023).

Scholastic competencies refer to the ability to demonstrate learning of academic subjects, including languages and related skills in Mathematics, Sciences, Social sciences, Languages etc., which are often measured by different forms of assessments.

Co-scholastic competencies which are generally addressed as co-curricular and extracurricular activities, refer to the ability to demonstrate learning of subjects beyond and besides academics, broadly categorised into Life Skills, Visual & Performing Arts, Attitudes & Values and Health & Physical Education (Kenneth et. al, 2012).

Life Skills may include Thinking, Social & Emotional Skills; Visual & Performing Arts may include Music (Vocal & Instrumental), Dance, Drama, Drawing & Painting, Craft, Sculpture, Puppetry, Folk Art etc.; Attitudes & Values may include combination of acceptable & desired behavior in personal & professional environment of Local, Regional, National & Global standards; Health & Physical Education may include Yoga, Physical Exercises, Scouting, Parading, Martial Arts, Sports (Indoor & Outdoor) including Swimming, Gymnastics etc.

Present Study

In the present study, a proposed inter-relationship between curricular, co-curricular and extracurricular activities and the mechanism through which these areas influence each other, has been attempted with respect to the results received from the study.

Efforts have been made to put forth to explain the process taking place in the brain while trying to boost scholastic competencies by adopting extracurricular activities involving Art and music applying multilingual skill activities in the remotely located rural school children of Vikarabad district of Telangana, India.

Purpose of the Study

In view of various reports from national agencies regarding low learning outcomes also termed as "Learning Crisis" and enhanced dropout rate in children from Government schools despite the government's best efforts to attract the rural children by way of providing good infrastructure, funds, food, human resources etc., it was felt necessary to formulate a combination of Co-curricular and Extra-Curricular activity program in conjunction with curricular concepts wherein the children get interested and motivated to learn thus enhancing learning outcomes. The recommendations of the study would be beneficial for the educational planners and managers.

METHODOLOGY: METHODS & TOOLS APPLIED

The project was implemented in 10 schools that were selected from 8 mandals of the Vikarabad district of Telangana state. About 800 children were chosen, with about 80 children per school. A pre and post-project assessment was carried out on the curricular subjects for all the 800 students (Table no.2), which was followed by 45 hrs of classroom facilitation for the children as per the coursework. The coursework consisted of 8 modules explicitly stressing on developing communication skills but implicitly aiming at curricular learning outcomes (Table no. 3). The training was followed by a demonstration/performance by each student in the classroom. The performance of each student was graded, and the results are compiled in Table no. 4. The program was followed by a post-project assessment on the topic covered in the curricular subjects. The pattern of the assessment was uniform

for all 10 schools. The assessment was carried out in an interview/quiz and verbal presentation mode.

Table 2: Format for pre- and post-project assessment in curricular subjects.

Sl. no.	Mode of assessment	Subject	Topic	Full marks
1	Maths: Viva-voce/ black board	Rational Numbers	General addition, subtraction, multiplication & division of rational numbers	20
		Ratio & Proportions	Solving simple problems in Per cent profit-loss, simple interest.	
		Simple Geometry	Area of Circle and a Square/ Volume of a Cube	
		Simple Statistics	Calculate mean of a given set of data	
2	Social Sciences: Quiz/ Interview/ Blackboard	Geography	Reading & analysis of Maps	20
		History	Freedom movement in Hyderabad State	
		Civics	The Indian Constitution	
3	Reading/ Recitation/ Interview	Languages		20
4	Science: Interview Black Board	Physical Sciences	Contact & non-contact Forces	20
			Writing Chemical Equations	
		Biological Sciences	Biodiversity & conservation	

Table no. 3: Details of the 8 modules, features and mode of activity

MODULE NO	CONTENT	FEATURES	Activity Mode
1.	Art of Introducing-Self	Bi-lingual	Solo
2.	Skill of Delivering a short talk: 'My School-My Pride'	Multi-lingual	Solo
3.	Learn to speak from Process Diagrams-English Grammar	English	Solo or in Pair
4.	Local Recipe-Language of process	Art-integrated & Multi-lingual	Solo or in Pair
5.	Outlook on District/State-Information-based opinion making	Multi-lingual	Solo or in Pair
6.	Local Poetic/Literary verses-using rhythm in language	Art-integrated & Multi-lingual	Pair or in a small group
7.	Language learning through singing-Rhythm & Tone	Art-integrated & English or foreign language or other state language	Large group
8.	Addressing Mock-Press Conference-Language of statements	Art-integrated & Multi-lingual	Large group

Table. No. 4: Assessment Scores of 8 modules for the 10 Schools during the project coursework.

Module NAME	*ZPHS KODANGAL (B)*	*ZHPS KODANGAL (G)*	*ZPHS YALAL*	*ZPHS AGGANOOR*	*ZPHS THANDUR*	*ZPHS BOMBRASPET*	*ZPHS MUJAHIDPUR*	*ZPHS MARIKAL*	*ZPHS PARIGI*	*ZPHS DOULATHABAD*
Self-Intro	67	68	66	69	74	75	73	73	74	74
My School My Pride/My Village	72	71	75	71	76	76	73	73	73	75
English Grammar	67	67	67	78	71	74	73	74	73	75
Local Recipe	72	68	75	74	75	74	74	74	73	74
An Outlook:Any Topic/Story	72	73	70	76	74	74	74	74	73	73
Poetic/Literary Versus	77	73	72	72	71	74	74	74	73	74
Singing for Language Learning	77	65	71	72	73	74	74	74	73	74
Mock Press Conference/S Kit	77	67	76	76	77	74	73	74	73	74
TOTAL	**73**	**69**	**71**	**74**	**74**	**74**	**73**	**74**	**65**	**74**

Table no. 5: Consolidated Results of Pre-Project Curricular Assessment

SL. NO.	**Subjects**	**TOTAL NUMBER OF STUDENTS**	**TOPIC**	**ASSESSMENT METHOD**	**TOOLS USED**	**NUMBER OF STUDENTS WITH % MARKS**			
						0-25 %	**26-40 %**	**41-60 %**	**61-100 %**
1	Maths	240	General addition, subtraction, multiplication & division of rational numbers	Viva-voce	Black Board	75	127	38	
		240	Solving simple problems in Per cent profit-loss, simple interest.	Viva-voce	Black Board	123	87	23	7
		240	Area of Circle and a Square/ Volume of a Cube	Viva-voce	Black Board	141	79	20	
		80	Calculate mean of a given set of data	Viva-voce	Black Board	22	50	8	
2	Social	320	Geography: Reading and analysis of maps	Quiz/ Interview	Audio Visual system	123	160	37	
		320	Histrory: Freedom movement of Hyderabad		Audio	132	152	26	10

					Visual system/ Black board				
		160	Civics: The Indian Constitution		Audio Visual system/ Black board	67	92	1	
3	Language	800	English/ Hindi/ Telugu: Poetry/ Prose reading	Reading/ Recitation/ Interview	Audio Visual system	275	390	135	
4	Science	400	Physics: Contact & non Contact Forces Chemstry: Writing Chemical Equations	Interview	Black Board	215	115	70	
		400	Biology: Biodiversity & Conservation		Audio Visual system/ Black board	170	130	85	15

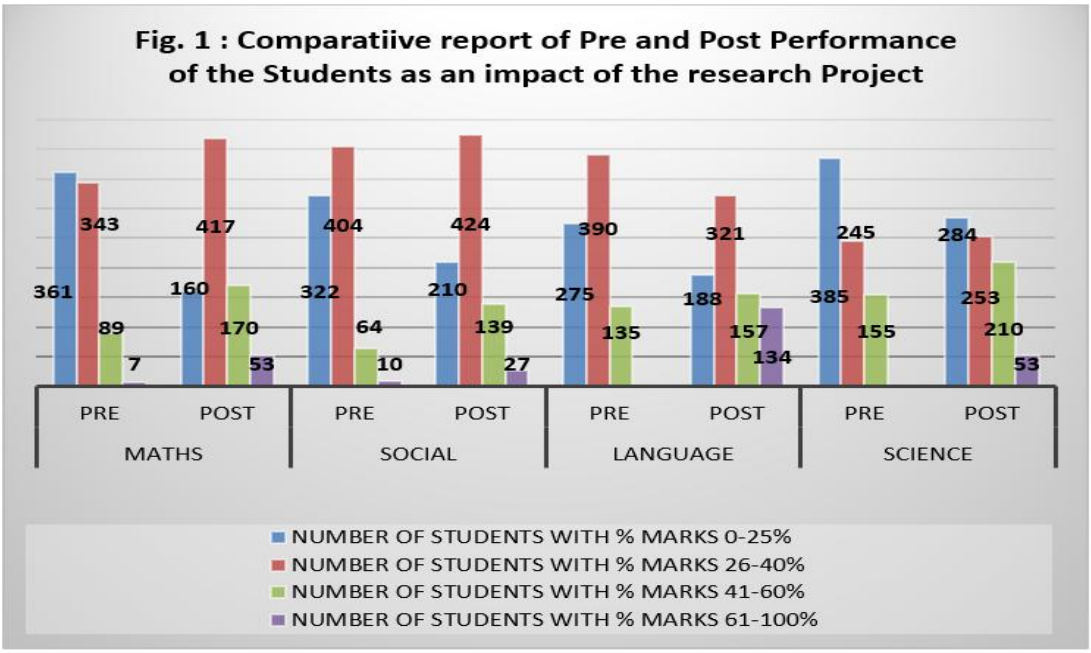
Table no. 6: Consolidated Results of Post-Project Curricular Assessment

SL. NO.	Subjects	TOTAL NUMBER OF STUDENTS	TOPIC	ASSESSMENT METHOD	TOOLS USED	NUMBER OF STUDENTS WITH % MARKS			
						0-25 %	26-40 %	41-60 %	61-100 %
1	Maths	240	General addition, subtraction, multiplication & division of rational numbers	Viva-voce	Black Board	35	137	50	18
		240	Solving simple problems in Per cent profit-loss, simple interest.	Viva-voce	Black Board	50	132	38	20
		240	Area of Circle and a Square/ Volume of a Cube	Viva-voce	Black Board	70	93	62	15
		80	Calculate mean of a given set of data	Viva-voce	Black Board	5	55	20	
2	Social	320	Geography: Reading and analysis of maps	Quiz/ Interview	Audio Visual system	80	170	61	9
		320	Histrory: Freedom movement of Hyderabad		Audio Visual system/ Black board	85	152	68	15

		160	Civics: The Indian Constitution		Audio Visual system/ Black board	45	102	10	3
3	Language	800	English/ Hindi/ Telugu: Poetry/ Prose reading	Reading/ Recitation/ Interview	Audio Visual system	188	321	157	134
4	Science	400	Physics: Contact & non Contact Forces Chemstry: Writing Chemical Equations	Interview	Black Board	179	110	89	22
		400	Biology: Biodiversity & Conservation		Audio Visual system/ Black board	105	143	121	31

RESULTS & DISCUSSION

Assessment was conducted during the project as part of the project protocol in all 8 modules. The results are presented in Table 4. The overall average score ranged between 69% to 74%. The score indicates that the students responded to the modules enthusiastically. Pre and post-project assessment scores have been presented in Tables no. 5 & 6. From the results, it can be observed that there has been a significant enhancement in the performance of the students in the curricular assessment after the project (Fig.1). It appears that the children have acquired the competency to absorb, process and recapitulate the information received by them. This shows that the children learnt the technique of developing the competency to acquire knowledge in the curricular field, through the co-curricular and extra-curricular activities, which have been broadly categorised under scholastic and co-scholastic fields.



We have tried to pinpoint the boundaries of scholastic and co-scholastic fields with sub-areas of curricular, co-curricular and extracurricular. The Fig.2 shows that there appears to

be an overlap between the three sub-areas marked as zone-1, 2 and zone-3. Although the three sub-areas are guided by separate objectives, namely Cognitive (Curricular), Affective (Co-curricular) and Psychomotor (extracurricular), there are learning outcomes which overlap and fall under zone-1, 2 and zone-3, which eventually support the adjoining subarea. Table no.6 depicts various experimental activities of the current research project, classified under curricular, co-curricular, extracurricular and the three zones.

Fig. 2: Venn Diagram representing the boundaries and subsets of Scholastic and Co-Scholastic fields

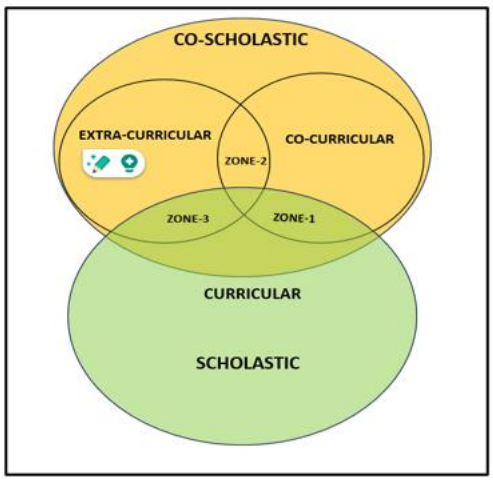


Table No. 7: Mapping of Curricular, Co-curricular and Extra-Curricular areas with reference to the modules of the research Project.

ACTIVITY	EXTRA-CURRICULAR	ZONE-2	CO-CURRICULAR	ZONE-1	ZONE-3	CURRICULAR
Introduce yourself			PUBLIC SPEAKING	Improves vocabulary and grammar usage.		LANGUAGE
Deliver a short talk			Extempore-Short talk	Enhances analytical thinking for structuring arguments		LANGUAGE
Teach a local recipe	DEMONSTRATION on recipe preparation	Improves fine motor skills (chopping, kneading, stirring). Develops hand–eye coordination.			Develops measurement and proportion skills (math integration) Enhances understanding of nutrition and food	MATHS SCIENCE LANGUAGE

					safety. Articulation of speech.	
Develop an outlook on District/ State			Prepared talk	Develops ability to organize ideas logically.		Language
Present a few local poetic/ Literary verses			Recites a poem in the local language	Strengthens memory through lyrics and melodies.		Language
Sing to enhance language learning	Singing an English song	Trains coordination between breathing, vocal cords & articulation. Enhances pattern recognition and auditory processing.		Strengthens memory through lyrics and melodies.	Improves understanding of rhythm and pitch.	Language Mathematical-musical link
Addressing Mock-Press Conference	Enactment of a play	Trains effective posture, body language, and gesture use. Improves coordination between listening and responding		Strengthens skill of content preparation. Enhances understanding of current affairs and civic issues.		Social sciences
Speak from Process diagram		Guides eye movement control for scanning and comprehension.		Develops visual literacy and interpretation skills. Enhances spatial reasoning and analytical thinking.		Language, Interpretation in geometry, physics diagrams

From the above mapping, apart from the Co-curricular activities, some of the extracurricular activities also contribute directly to the improvement of curricular achievements.

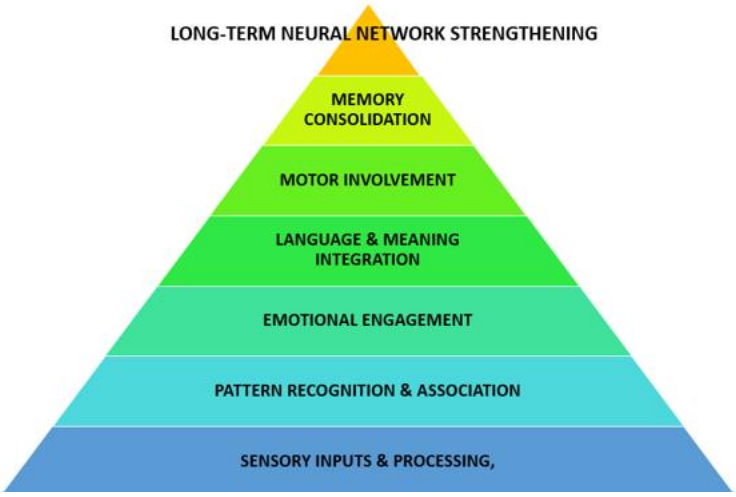
Consequently, an attempt is made to understand and sequence the brain processing during the extracurricular activity carried out by the children in the classroom. Table no. 7 and Fig. 3 show that the first information input to the brain is received by the Auditory, visual and Somatosensory cortexes, followed by pattern recognition and association by the neurons and Hippocampus. Parallelly, the Amygdala responds by way of emotional engagement. The third sequence for the learner is the language & meaning integration at the BROCA's & WENICKE's area. The last sequence of the activity are the motor involvement, memory consolidation and long-term neuron network strengthening, which is controlled by the Synapses and Corpus Callosum. (Gago & Elgier, 2018).

Table no. 8: Mapping of the Brain Activity during the process of learning through Extra-Curricular Activity.

Processing sequence	**Brain processing during learning**	**Part of the brain involved**	**Progress learning process**
1	Sensory input & early processing	Auditory cortex (temporal lobe)	Activates pitch, rhythm & melody aspects
1		Visual cortex (occipital lobe)	Involved in reading of lyrics
1		Somatosensory & motor cortex	Singing, clapping or moving to the beat
2	Pattern recognition & association	Neurons & hippocampums	Strengthening of neuron network to detect music patterns, hippocampus links these music patterns with curricular concepts to create a memory pattern.
2	Emotional engagement	Amygdala	Processes emotional tone of the music & boosts dopamine release, thus increasing motivation and enabling reinforcement of memory encoding.
3	Language & meaning integration	Broca's (speech production) & wenicke's area (language comprehension)	Lyrics processing or verbal explanations embedded in the song, multilinual lyrics activates multiple language networks, expanding neural cross-talk.
4	Motor involvement	Motor cortex & cerebellum	Enhancement of procedural learning and timing coordination, strengthening of multi-modal memory encoding.
5	Memory consolidation	Hippocampus & neocortex	During slow wave & rem stages of sleep, hippocampus links music tune with the concepts, activity, consolidates and transfers to neo cortex as long-term memory. Music acts as a cue, even a snippet of the tune can trigger the recall of the concept.
6	Long-term neural	Synapses, corpus callosum	Repeated exposure to song

	network strengthening		& concept strengthens synaptic connection (hebbian learning). Corpus callosum creates a communication channel between hemispheres (left: language, logic; right: melody/ emotions), thus reinforcing a strong, resilient memory

Fig. 3: Broad Sequencing of Brain Processing During the learning of Concepts through Extracurricular and Co-Curricular Activities.



CONCLUSION

The present research study highlights that learning is not a linear or isolated process but an integrated brain activity wherein multiple regions interact dynamically. When a child learns a curricular concept with **multilingual exposure and combination of co-curricular** and **extracurricular activities**, the neural pathways are strengthened by cross-domain stimulation involving language centers (Broca's and Wernicke's areas), executive control regions (prefrontal cortex, anterior cingulate cortex), sensory–motor areas, and emotional–memory circuits (amygdala and hippocampus). The sequence of brain processing observed confirms that multilingual engagement enhances cognitive flexibility and conceptual clarity, while extracurricular participation—such as music, art, or public speaking—activates reward and motivation pathways, thereby deepening attention, retention, and transfer of learning.

This synthesis of curricular, co-curricular, and extracurricular strategies fosters **holistic brain development**, making learning more enduring and meaningful. Therefore, an education system that purposefully integrates **multilingual instruction and diverse activities** alongside core academics can optimize not only knowledge acquisition but also creativity, problem-solving, and socio-emotional growth, ensuring that children are prepared for the complexities of the future.

Besides, it is observed that co-scholastic education can mitigate absenteeism, reduce drop-out rate, and conversely, increase enrolment and learning outcomes, thus contributing to

quality education. More importantly, it helps serve as an opportunity for a diverse group of learners, especially among low academic achievers, to experience and achieve success that contributes to enhancing academic inclusivity.

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Conflict of Interest

The author(s) declared no conflict of interest.

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