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NEUROCOGNITIVE AND DIGITAL PATHWAYS TO ENGLISH FLUENCY: A SAMR-BASED CONSTRUCTIVIST APPROACH FOR RURAL LEARNERS

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ABSTRACT

This theoretical study examines English speech through a neurocognitive perspective. It seeks to elucidate how Tamil-speaking students in the rural areas process phonological, auditory and working memory processes as they adapt to an English-medium environment. Through the application of phonological loop principles and auditory written language, the paper underscores issues like limited phoneme differentiation, constraints in working memory processing, and challenges in assessing rhythm and stress in the English language. To assist these learners in overcoming their challenges, a constructivist framework that aligns with SAMR (Substitution, Augmentation, Modification, Redefinition) will be provided by implementing digital tools that serve as neurocognitive aids. At the substitution and augmentation stages, software that provides visual depictions of phonemes, converting speech into visuals like waveforms, pitch contours, and spectrograms allows learners to compare their spoken output with native speakers' pronunciation in English. This comparison improves their auditory perception and the motor aspects involved in sound production. The input stimulates visual and auditory pathways to enhance phonological awareness and verbal accuracy. During the modification and redefine phase, tools like virtual reality speaking (or social skills) simulations and AI-powered pronunciation trainers will be utilized to improve speaking skills, develop speech motor functions, and strengthen neural connections—all aimed at enhancing communicative competence (bilingual fluency and speaking self-assurance) in language learners by maximizing the time they engage in the target language through pattern recognition, metacognitive self-evaluation, and input adjustments.

Keywords: Neurocognitive Processing, Phonological Awareness, Phoneme Visualization, Working Memory, Auditory Discrimination, SAMR Model, Constructivism

INTRODUCTION

Mediated English speaking is a continual challenge for Tamil-medium and pastoral scholars in India because of limited exposure to English sound, limited working memory, and limited phonological mindfulness. Tamil-medium learners struggle with relating and discerning phonemes, feeling stress and meter, and producing bearing speech in formal and informal situations Prabhu and Somashekara (2024). This is particularly worrisome in pastoral situations where openings for digital architectures and exposure to speaking, English, phonology, etc. are limited, which further limits the openings to distinguish or hear phonemes. Multimedia technology can potentially transfigure phonological mindfulness-grounded conditioning into practical uses that can enhance phonological mindfulness/ignorance and pronunciation with printouts and charts of the ways Sapi'ee and Tan (2020). To combat the challenges associated with Tamil-medium scholars and pastoral English-medium scholars, the National Education Policy (NEP)

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2020 highlights the significance of a comprehensive technology-guided approach to close verbal and cognitive gaps around linguistically/cognitively loaded ELT. It's described as a learner-centered, digital agency with an intimately driven design imperative ecosystem that guarantees all a fair chance at quality English language education. Including multilingual language capability, and in the social services environment, scholars of pastoral marginalized populations to advanced performance in language issues IJFMR (2025).

This new focus on connecting the digital world to purposefully integrated multimodal literacy tools pedagogy in the classroom, recognizes the neurocognitive understanding that active, interactive (or multimodal) lead to advanced audile processing, boosting phonological sound differences and the capability to produce achieve fluid speech coupled with the exertion of interpreting and discerning language In this sense, the SAMR model—Negotiation, Addition, Revision, Redefinition—approaches technology integration into language tutoring in a methodical way dos Santos et al. (2022), while constructivism provides the pedagogical platform for active, existential, and cooperative literacy that engages learners in co-generating understanding through mingled reflection Guo (2024). The confluence of these two fabrics creates a literacy terrain in which scholars develop abstract understanding through commerce, reflection, and personification, neuro constructivist principles critical to language development and ignorance Ali (2022). This study addresses the dearth of original descriptive models that integrate neurocognitive propositions, digital tutoring, and constructivist classroom approaches in promoting English-speaking ignorance. While neurocognitive exploration has established the significance of phonological processing, audile demarcation, and working memory in alternate language accession Prystauka et al. (2023), it's pivotal for this exploration to translate these aspects of neurocognition into practicable digital tools for the classroom.

Digital pedagogical models stick learners for active and reflective participation in a learner-centred manner, especially when promoting scholars' cognitive engagement in language and communicative practices through interactive technological configurations Väätäjä and Ruokamo (2021), Szabó (2023). As well, English Language Teaching (ELT) exploration indicates that the objectification of technology into pedagogical models like SAMR highlights learner independence, provocation, and communicative ignorance—especially when applied through constructivist tutoring Kadel and Tiwari (2025). Accordingly, this study will consider exemplifications pressing how SAMR and constructivism can concertedly foster phonological mindfulness, audile demarcation, and speaking confidence through technology-grounded, pupil-centered English language tutoring. The document is arranged into sections presenting the theoretical fabrics, review of literature, development of the abstract frame, and educational counteraccusations for inclusive ELT within pastoral areas.

LITERATURE REVIEW

The SAMR framework represents a significant point of departure for considering technology in the context of English Language Teaching (ELT), as it allows educators to move from implementing a basic substitution to a transformative redefinition of the activities they plan for their students. One scoping review found that SAMR offers educators a way to approach a systematic assessment of digital integration, which is particularly useful with blended and online learning spaces Blundell et al. (2022). The study conducted by dos Santos et al. (2022) incorporated SAMR applications based on ICT in ELT courses, including podcasts, language learning applications, and learning management systems, that facilitated student engagement and collaboration. Research continues to focus primarily on reading and writing skills, especially those involving reading and writing alike, but cases reliance on tasks perceived as useful results in reduced emphasis on speech production and the neurocognitive skills needed for phonological awareness and auditory discrimination tasks Blundell et al. (2022).

The impact of constructivist teaching, which promotes student choice, reflection, and collaboration, is significant on both speaking fluency and confidence. According to Szabó (2023), digital collaborative tools, such as Padlet and audio journals, increased engagement and peer support in language learning environments. Developmentally appropriate practice, Padlet, has increased oral responses for peer feedback, more motivation from learners, and increased spoken interaction among learners, to improve pronunciation Sari (2019). However, as of now, most studies have focused on confidence and communicative fluency, rather than phonological or neurocognitive measures related to speaking performance Szabó (2023), Sari (2019).

Neurocognitive and educational studies continue to find that multisensory digital resources enhance working memory, auditory differentiation, and phonological awareness—all of which are important processes in developing second-language speech. Prystauka et al. (2023) stated that the phonological loop and auditory processing are fundamental cognitive operations that support L2 fluency. Supporting this, Raposo-Rivas (2024) found in a meta-analysis that multimedia and visualization tools improved learner's ability to identify and produce phonemes, helping to build practice using AI to support pronunciation and rhythm. However, most of these studies are experimental or literacy-based instead of focused on classroom speaking instruction Prystauka et al. (2023), Sari (2019).

The synthesis underscores a notable research gap. Research using the SAMR model utilizes rarely as a construct focused on either speaking production or cognitive processing while research on digital-constructivist approaches highlight confidence but do not attach any confidence boosts to phonetic or neurocognitive gains. Furthermore, technology and cognition studies point to functionality but do not adjust for rural Indian or Tamil-medium contexts that have persistent language and infrastructure challenges, Kadel and Tiwari (2025). Only a handful of studies dabble at blending the SAMR, constructivism, and neurocognition

theories into a model. This research proposes a descriptive SAMR-Constructivist framework that marries digital pedagogies and cognitive principles to support English speaking proficiency of students from rural background.

THEORETICAL FRAMEWORK: INTEGRATING SAMR, CONSTRUCTIVISM, AND NEUROCOGNITIVE PRINCIPLES

This study relies on three theoretical frameworks—neurocognitive linguistics, the SAMR model of technology integration, and constructivist learning theory—which together illustrate how digital, multisensory environments can promote language production for rural Tamil students.

The SAMR model (Substitution, Augmentation, Modification, and Redefinition) demonstrates how technology use evolves from mere replacement to transformative educational experiences Puentedura (2013). In Substitution, technology is a direct tool substitute with no functional change (e.g. students listen to audio instead of the teacher reading a text). In Augmentation, the substitute technology offers functional improvement such as a speech to text application telling students when they pronounced a word incorrectly. In Modification, the enhancement allows a redesign of the task, such as having students perform pronunciation tasks together with a waveform output that gives both aural and visual feedback. Finally, in Redefinition, the students partake in a task that was not impossible, such as an AI speaking simulation that uses interactive conversation that offers an immersive and peer-assisted context. Research indicates that the highest levels of SAMR (Modification/Redefinition) are closely related to a transformative learning experience Romrell et al. (2014).

Constructivist theory, as explained by Piaget, Vygotsky, and Bruner, stresses that learners actively build knowledge via experience, social engagement, and reflection. In the field of language acquisition, social constructivism highlights the significance of collaborative interactions among peers and structured activities in improving speaking abilities Szabó and Csépes (2022). Tasks focused on learners, teamwork, and significant interactions foster enhanced cognitive processing, improved fluency, and learner independence Bada (2013).

The synergy of SAMR and constructivism forms the conceptual backbone of this paper: as learners ascend the SAMR ladder, their tasks become more interactive, socially oriented and reflective, thereby aligning with constructivist principles. The earlier SAMR stages support foundational neurocognitive processes (such as auditory discrimination and working memory).

while higher stages activate deeper engagement, social co-construction and metacognitive monitoring. In doing so, this framework addresses how neurocognitive processes can be supported via technology and learner-centred pedagogy to develop English speaking proficiency among rural Tamil learners.

METHODOLOGY AND APPROACH

This study employs a descriptive-theoretical design that is ideally suited for conceptualizing pedagogical models from the literature rather than collecting empirical data. Descriptive-theoretical studies use previously proven research to create new interpretations or models, which is a popular approach in education and social sciences Snyder (2019). The "data" that this study uses comes from peer-reviewed literature, theoretical discussions, and educational assessments…using approaches that Webster and Watson (2002) suggest for systematic conceptual review.

The methodological framework includes three conceptual elements: the SAMR model for technology integration, constructivist learning theory, and neurocognitive frameworks with regard to phonological processing, auditory discrimination, and working memory. Research frameworks in neurocognitive linguistics Baddeley (2012) were consulted to understand how multisensory input supported the phonological loop and processing speech. Research related to digital pedagogy and the SAMR model Romrell et al. (2014) supported the analysis of how the technology allows tasks to be reconfigured, and principles of constructivism were established in accepted literature related to educational theories Bada (2015).The examination aligns digital speaking tasks—like speech-to-text feedback, waveform visualization, and AI pronunciation aids—with SAMR tiers and constructivist components such as scaffolding, teamwork, and reflective learning. This combined approach facilitates the development of a coherent conceptual framework to improve English speaking skills among Tamil learners in rural areas.

DESCRIPTIVE FRAMEWORK: SAMR–CONSTRUCTIVIST MODEL FOR ENGLISH SPEAKING

The SAMR-Constructivist model demonstrates how gradual use of digital tools contributes to the neurocognitive functions needed to develop English speaking skills.

Substitution level, technology acts as a simple replacement for traditional listening and repetition exercise practices. Having access to quality digitally recorded audio models increases early- phonological encoding because research has shown that continual auditory exposure significantly increases L2 phoneme discrimination and accent accuracy Flege and Bohn (2021).

Augmentation level, digital tools also enhance functionality and provide real-time, interactive feedback. Learners can use speech-to-text tools and waveform displays to begin to compare their pronunciations to expected models. Research has shown that providing visual–acoustic feedback in the phonological modality increased L2 phoneme distinctions and accuracy in segments,

especially when learners struggle with unfamiliar sound contrasts Kartushina and Martin (2019). At this phase, learners practice phoneme identification, auditory comparison, and begin to create modality (auditory-visual, audio-motor) integration, all of which are neurocognitive aspects of speech development.

Modification phase signifies a major revision of tasks aligned with constructivist principles such as collaboration, scaffolding, and social interaction. Students engage in online discussions, record peer conversations, and participate in AI-driven pronunciation activities. Research indicates that collaborative speaking tasks in a second language (L2) improve fluency, rhythm, and interactional competence by promoting deeper meaning negotiation and providing immediate feedback Sato and Ballinger (2016). Furthermore, AI-based pronunciation systems have been shown to improve suprasegmental features like stress and intonation through personalized corrective feedback Neri et al. (2020).

Redefinition phase, technology enables experiences that are impossible in traditional classroom settings, such as VR storytelling, conversations with avatars, and podcasts developed by classmates. Immersive VR environments have been linked to increased confidence in L2 speaking and more spontaneous verbal expression by reducing anxiety and enhancing authenticity Lan et al. (2020). Producing podcasts also fosters creative, goal-oriented speaking while supporting long-term memory retention through practice and self-reflection Chacón-Beltrán (2018). Progressing through the SAMR levels aligns with constructivist educational theories and enhances neurocognitive functions—providing a comprehensive, evidence-driven digital pathway for improving English speaking abilities.

DISCUSSION AND PEDAGOGICAL IMPLICATIONS

INTEGRATION OF SAMR AND CONSTRUCTIVISM IN SPEAKING PRACTICE

Integrating the SAMR model's technology increases and encourages active speaking practice from operational fluency from simply a repetition of educational tasks. The transfer from substitution and augmentation to modification and redefinition reflects movement from mimetic practice to creating something new. As, in the existing research, it supports the findings that instructional tasks supported by digital media foster learner independence and creation within the practice than passive creation Zhang et al. (2025). This approach enhances the cognitive and social dimensions of speaking development by matching technology levels to the learner-cantered tasks.

TECHNOLOGY AS MEDIATOR AND SCAFFOLD FOR LANGUAGE COGNITION

Digital resources act as intermediaries by providing multisensory inputs (auditory, visual, interactive) and supports by providing coordinated feedback and collaboration. For example, digital storytelling applications have been shown to improve speaking fluency based on motivated, collaborative and reflective practices of students in rural contexts Nair and Md Yunus (2022). These resources enhance cognitive functions, the phonological loop and working memory by giving immediate feedback, self-assessing, and encouraging intentional practice.

Digital tools play the role of intermediaries through providing multisensory input (auditory, visual, and interactive) and the role of tools by providing systematic feedback and collaboration. For example, digital storytelling tools have been shown to improve speaking fluency through increased motivation, collaboration, and reflection, among students in rural settings Nair and Md Yunus (2022). These tools also aid cognitive processes—such as phonological loop and working memory—by providing real-time feedback, facilitating self-evaluation, and encouraging purposeful practice.

RURAL ADAPTABILITY IN LOW-RESOURCE CONTEXTS

Cost-effective digital tools (e.g., smartphones, basic recording applications, online platforms for collaboration, etc.) can augment each SAMR stage, even in rural areas with limited resources. The National Education Policy 2020 promotes technology-cantered multilingual education with equitable access; recontextualizing this model for rural settings will ensure inclusive implementation. Research demonstrates that rural students, given appropriate technology affordances and designed activities, can participate meaningfully in digital speaking assessments, despite limited infrastructures Mudra (2025).

APPLICATION AND PEDAGOGICAL IMPLICATIONS

The pedagogical significance of this descriptive SAMR-Constructivist neurocognitive framework underscores the need for teachers to develop multisensory, task-centred speaking activities that elicit cognitive engagement and build language proficiency. In the early SAMR stages, teachers can introduce fundamental digital listening and recording tools that stimulate phonological encoding and auditory discrimination, with research revealing the effect of multimedia input on EFL speaking accuracy Hsu and Yang (2013). Once students reach Augmentation and Modification stages teachers, should incorporate interactive speech-processing technologies, collaborative audio platforms, and peer-review feedback systems that act as cognitive scaffolding. These scaffold working-memory rehearsal, phoneme-visual correspondence, and metacognitive control which are supported by evidence that mobile speaking activities enhance fluency, independence, and verbal performance Klimova (2021).

Digital activities designed around various constructivist approaches, including collaborative voice threads, interactive narratives, or jointly created dialogues, foster agency, critical thinking, and collective understanding, echoing results from earlier research indicating that technology-enhanced collaboration was intended to aid communication and reduce anxiety in EFL settings Chen and Hwang (2020). In the redefinition phase, immersive technologies utilized for role-playing in VR and collaborative work on digital storytelling foster authentic communicative environments that enhance neuroplasticity and accelerate the growth of spontaneous speech skills.

These investigations demonstrate that VR settings for spoken practice learning offer considerably greater levels of oral confidence, chances for engagement, and communication skills Lin and Lan (2022). Teachers in rural locations or lacking resources can still participate in these activities through inventive and low-cost mobile collaborative tasks by using mobile recording apps, offline pronunciation applications, and various collaborative tools. Studies have demonstrated that effectively designed mobile learning activities can continue to foster student agency, learning, and practice Shadiev and Yang (2020). These results align with the National Education Policy 2020 by fostering inclusivity, tech-enhanced learning, and multilingual involvement. The SAMR-Constructivist model provides a unique approach to engagement for educators, beginning with basic digital interactions, fostering learning through teamwork and interactive tasks, and facilitating transformative communication opportunities that students create, based on their initial and sometimes temporary use of technology as a medium for collaboration.

CONCLUSION

Digital activities designed around various constructivist approaches, including collaborative voice threads, interactive narratives, or jointly created dialogues, foster agency, critical thinking, and collective understanding, echoing results from earlier research indicating that technology-enhanced collaboration was intended to aid communication and reduce anxiety in EFL settings Chen and Hwang (2020). In the redefinition phase, immersive technologies utilized for role-playing in VR and collaborative work on digital storytelling foster authentic communicative environments that enhance neuroplasticity and accelerate the growth of spontaneous speech skills. These investigations demonstrate that VR settings for spoken practice learning offer considerably greater levels of oral confidence, chances for engagement, and communication skills Lin and Lan (2022). Teachers in rural locations or lacking resources can still participate in these activities through inventive and low-cost mobile collaborative tasks by using mobile recording apps, offline pronunciation applications, and various collaborative tools. Studies have demonstrated that effectively designed mobile learning activities can continue to foster student agency, learning, and practice Shadiev and Yang (2020). These results align with the National Education Policy 2020 by fostering inclusivity, tech-enhanced learning, and multilingual involvement. The SAMR-Constructivist model provides a unique approach to engagement for educators, beginning with basic digital interactions, fostering learning through teamwork and interactive tasks, and facilitating transformative communication opportunities that students create, based on their initial and sometimes temporary use of technology as a medium for collaboration.

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