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AI-enabled networked learning: A posthuman connectivist approach in an English for specific purposes classroom

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Abstract

This study investigates the efficacy of artificial intelligence in facilitating networked learning that aids educators in creating inclusive and academically responsible learning environments in Indian English for Specific Purposes (ESP) classrooms. Designed as a qualitative case study, the intervention involves twenty participants from an engineering institute in India, who engaged with AI and chatbots in pairs to learn and build on their content knowledge on sustainable practices in engineering. The theoretical foundation for the study is grounded in Vygotsky's Zone of Proximal Development (ZPD) model and the theory of Connectivism, both of which were utilised for an in-depth data analysis. This exploration posits that the process of learning involves connecting various information sources and the ability to make connections between and across discourses, concepts, fields and experiences. Therefore, the non-linearity in learning involving human, non-human and technological resources is analysed through the connectivism theory (Siemens, 2005a, b & Downes, 2005a, b). The findings of the study discuss the pedagogical implications of incorporating AI and chatbots among tertiary-level learners and examine the ethical and social consequences of accommodating them in the learning assemblage. The results of the study will also enable educators to formulate strategies to include AI in teaching and learning methods through the affordances of connectivism.

Keywords Artificial intelligence · Zone of proximal development · Connectivism · Higher education · English language learning · Large language models

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1 Introduction

The technological advancements over the years have impacted and shaped educational practices, particularly in language learning. The integrated approaches to language and technology such as Computer-Assisted Language Learning (CALL) and Mobile-Assisted Language Learning (MALL) have demonstrated how digital tools can enhance learning outcomes (Davies et al., 2013; Dudeney & Hockly, 2012). Higher education institutions recommend using technologies such as artificial intelligence (AI) to create an interactive learning experience (Adu et al., 2022).

More recently, the proliferation of Large Language Models (LLMs) such as ChatGPT (Chat Generative Pre-trained Transformer), Gemini, LLaMA (Large Language Model Meta AI), Language Translation, and many others, which can generate texts that are human-like and answer questions with great level of accuracy, has given rise to a potential interest in exploring its application in the field of education.

LLMs such as ChatGPT and Gemini have tremendously impacted educational practices. Studies reveal that LLMs develop English language skills (Wang & Guo, 2023), facilitate personalised learning (Tlili et al., 2023), provide feedback (Kohnke et al., 2023) and motivate the learners (Ali et al., 2023). LLMs can also take up roles of being assistants, material generators, assessors and interlocutors (Jeon & Lee, 2023). However, it also poses negative impacts. For instance, an increasing number of colleges and institutions are open to returning to the more conventional pen-and-paper evaluation forms in response to the increased risk of unethical behaviour (Tlili et al., 2023). Academic disintegrity is not a novel issue; it has existed in educational institutions where learners find ways to gain an unfair advantage over others in the classroom (Adeshola & Adepoju, 2023; Rowe, 2004). However, recent technological advancements such as ChatGPT and Gemini have raised serious concerns about academic dishonesty (Pavlik, 2023). Similarly, despite plagiarism being an existing problem, scholars point out that ChatGPT and other such LLMs raise worries about academic integrity and add a new dimension to the risks of cheating and plagiarising (Kostka & Toncelli, 2023; Cotton et al., 2024). Studies also assert that using AI may hinder learners' improvement of writing skills, critical thinking and problem-solving abilities (Susnjak & McIntosh, 2024). The adverse effects of AI in academia are not just limited to dishonesty and have the potential to have an overall negative impact on learning and the education system (Adeshola & Adepoju, 2023).

While many studies have suggested ways to address the challenges posed by AI tools, such as implementing advanced plagiarism detection tools or redesigning assessment methods, there remains a significant gap in understanding how to integrate ChatGPT into the learning process effectively, ensuring its responsible and ethical use (Rahman & Watanobe, 2023). Although some research offers preliminary suggestions, the practical implementation and applicability of these strategies in real educational settings remain unclear. In response to these

growing concerns, Hockly (2023), in his study, asserts the need for improvement in the digital competencies and strategies to utilise AI and technology responsibly in a classroom space that is ethical and pedagogically beneficial. Digital competencies encompass not only technical proficiency in operating digital devices but also the social and emotional dimensions of utilising and comprehending them (Zhao et al., 2021). Therefore, to effectively and responsibly interact with LLMs for learning purposes, proficiency in engaging with the tool's interface, as well as a comprehensive understanding of its capabilities and limitations, become a prerequisite. Additionally, it requires the learners to be cognizant of ethical considerations, including issues of bias and privacy (Adeshola & Adepoju, 2023). Consequently, individuals with limited digital competence may struggle to use ChatGPT effectively, potentially overlooking critical aspects of its responsible application.

Therefore, research on LLMs in education has primarily focussed on their potential for enhancing learning and the associated risks, including plagiarism and overreliance. While some studies mention the need for digital literacy (Hockly, 2023), practical suggestions as to how educators can systematically implement responsible use of AI in classrooms are limited. Furthermore, existing frameworks for AI integration often neglect the connectivist perspective, which emphasises learning through networks, shared knowledge, and active participation in digital environments. This paper seeks to address this gap by documenting the affordances of LLMs through an intervention that would aid educationists in formulating strategies for the responsible and effective use of AI in education. This study also explores the possibility of new teaching and learning methods in an ESP classroom that incorporate AI and LLMs from the perspective of Vygotsky's More Knowledgeable Other (MKO) and posthuman connectivist approach.

The theory of Vygotsky places a strong emphasis on learning through social interaction, interpersonal communication and collaboration with the help of an MKO. Therefore, analysing LLMs as MKO in providing support and assistance to learners in this study can expose their affordances in the learning process. This is particularly beneficial in the context where learners have different learning needs and styles and may require additional assistance. Similarly, the theory of connectivism developed by Siemens (2005a, b) and Downes (2005a, b) emphasises the significance of networks and connections in the learning process. As we live in posthuman times where technology is constantly evolving and challenging the agency of humans, in the field of education, connectivism as a learning theory can provide a framework for understanding the complexities involved in learning by acknowledging the potential of networks and technology (Omodan, 2023). A networked education system/learning process is rooted in a decentralised, non-hierarchical, and multi-directional infrastructure (Castells, 2000). This approach underscores how technology and humans are interconnected. As LLMs provide access to information and collaborate with the learners in their learning process, they can break down barriers and promote inclusivity.

Therefore, by combining connectivism with Vygotsky's MKO, this qualitative case study explores how LLMs can be used to create a more inclusive and responsible learning environment. It examines the efficacy of LLMs and AI chatbots as

pedagogical tools in an English for Specific Purposes (ESP) classroom in South India. The study also aims to illustrate the non-linear and networked learning involving human, non-human and technological resources from a posthuman theoretical perspective.

2 LLMs in language learning and education

LLMs such as ChatGPT and Gemini can facilitate personalised and effective learning experiences (Kasneci et al., 2023; Tlili et al., 2023) and provide interactive feedback (Kohnke et al., 2023). Various studies assert that LLMs can improve English language skills such as reading (Ali et al., 2023), grammar and vocabulary (Wang & Guo, 2023), and writing skills marked by improved content and organizational structure (Allagui, 2023; Fitria, 2023). Using LLMs can have a positive impact on the motivation level of the learners to develop their language skills. For instance, Ali et al. (2023) explored the influence of LLMs in improving the motivational aspects of the learners and found that learners were motivated to enhance their reading and writing skills. This could also be because of the personalised inputs and feedback provided by the chatbots (Kohnke et al., 2023). Similarly, Jeon and Lee (2023) investigated the role of ChatGPT and affirmed that LLMs can play four roles in the learning process, including being a teaching assistant, material generator, assessor and interlocutor.

At the higher education level, LLMs can enhance critical thinking and problem-solving skills and encourage the development of research skills (Kasneci et al., 2023). However, very few empirical research studies support this claim. It has been reported that students will require digital/AI literacy skills to comprehend humans and machines (Long & Magerko, 2020) and prepare for a future with rapid technological advancements. Additionally, there are also other pressing concerns regarding the use of LLMs in education. For instance, Chomsky refers to LLMs as 'high-tech plagiarism' (Stewart, 2023), which adds a new dimension to the already existing issues related to unethical practices and plagiarism (Kostka & Toncelli, 2023; Cotton et al., 2024). Sullivan et al. (2023) state that despite the positive impacts of LLMs in education, academic integrity was a common concern in most studies. This adds to the claims that motivation to cheat during assessments and academic submissions becomes higher due to the accessibility and ease that AI and LLMs offer (Kostka & Toncelli, 2023). Similarly, LLMs may provide the users with false information that can be stereotypical and inaccurate, which requires the learners to critically evaluate the data (Heaven, 2023). This study adds to the literature by documenting the impact of LLMs as pedagogical tools in a language classroom in developing the content knowledge of the learners that would require them to operationalize their critical thinking and research skills. It also explores the possibility of creating inclusive and academically responsible learning environments by incorporating technology, especially LLMs, which has not been investigated before.

3 Research questions

The study focuses on the effectiveness of using Large Language Models (LLMs) and AI Chatbots in an English language classroom and aims to explore the following research questions:

1) How do LLMs and AI chatbots support learners and educators in creating inclusive and academically responsible learning environments in an English for Specific Purposes (ESP) classroom?
2) What are the pedagogical implications of accommodating LLMs and AI Chatbots in developing the content knowledge of the learners?

4 Theoretical framework

This study is placed within a framework comprising two major theories. Firstly, the theory of Connectivism, which has emerged as a response to the evolving terrain of education in the digital age where learning is no longer an individualistic activity, highlights the importance of technological tools and social networks in the learning process. Developed by Siemens (2005a, b) and Downes (2005a, b), it emphasises the significance of networks and connections in the learning process. In other words, it asserts that learning occurs through the process of connecting various information sources, establishing connections between humans and humans and technology. The principles of connectivism (Fig. 1) suggest that learning rests in a diversity of thoughts and may also reside in non-human appliances. It asserts that the ability to draw connections between fields, ideas and concepts and the potential to know more is crucial than what is already known. The theory also propounds that maintaining and nurturing connections to promote continual learning is important to have up-to-date knowledge, and the learners can choose what to learn. Therefore, while other language theories such as cognitivism, behaviourism and constructivism emphasise the individual's independent learning experience, this theory underscores the connected learning experiences of individuals (Jung, 2019), which aligns more with the sociocultural theory of learning espoused by Vygotsky.

Many studies exploring technology and online communications in learning have employed connectivism theory to examine how the connections between learners, technology, and online and offline communications increase connectivist knowledge, reflection, and negotiation (Liu et al., 2023; Sozudogru et al., 2019; Su et al., 2023). Social and technological networks are increasingly being used to foster learner connections. Aksal et al. (2013) applied connectivism principles on Facebook in a 16-week qualitative study, highlighting its role in facilitating learning and developing leadership, decision-making, and critical reflection. Similarly, Wang et al. (2018) explored connectivism in a 36-week MOOC, emphasising how different online platforms enabled knowledge sharing and varying degrees of learner connectivity. With regards to professional development, Davoodi (2024) asserts that connectivism fosters dynamic knowledge networks, enabling a shift

Fig. 1 Principles of connectivism

in educators' perceptions of AI from apprehension to empowerment. However, when it comes to GenAI tools such as LLMs, their role in fostering connectivist learning is still evolving. While studies applying connectivism theory to AI tools such as ChatGPT are limited, one notable study by Liang and Bai (2024) examines how GenAI tools support learning in social entrepreneurship education by fostering collaborative learning, knowledge connectivity, and theory–practice integration through networked interactions. Advancing the discussion in this emerging field, this study adopts connectivism as a theoretical framework. Given the complex and interconnected nature of AI tools such as ChatGPT in learning environments, Connectivism serves as an ideal theoretical framework for this study. As a theory that emphasises knowledge acquisition through networks of human and technological interactions, Connectivism aligns with the study's focus on using LLMs to enhance learners' content knowledge while promoting its responsible use.

In the current scenario, where the individualistic agency of humanism is questioned, teaching and learning are no longer an encounter between two or more humans. It involves various other factors such as technology, to start with. Omodan (2023) argued that in posthuman times, where technology is constantly evolving and challenging the agency of humans, connectivism as a learning theory can provide a framework to understand the complexities involved in learning by acknowledging the potential of networks and technology.

The posthuman approach recognizes the significance of technology in the everyday assemblage (Buchanan-Oliver, 2015), foregrounds the interconnectedness of all things (Hasse, 2022) and rejects the binary between the human and the non-human. In other words, posthumanism debunks hierarchy and affirms that everything (human, non-human, machine, ideas, etc.) is relational and connected. A posthuman classroom, therefore, integrates technology as a medium more than a mere tool in all aspects of learning. It facilitates multiplicity in learning, that is, multiple ways of accessing and interacting with information inside and outside the confines of the classroom. Hence, the theory of connectivism parallels the theory of posthumanism by asserting the non-binary relation between humans and machines and accounts for their interaction with each other to learn and create knowledge. See (Fig. 2) to perceive the connections between the two theories.

The second theory used in this study is Vygotsky's Zone of Proximal Development (ZPD), which is a part of his socio-cultural theory (Vygotsky, 1978). According to Vygotsky, the ZPD is the difference between the current development level of the learner and the potential development of the learners, which can be attained through the mediation of a More Knowledgeable Other (MKO). This theory places a strong emphasis on learning through social interaction, interpersonal communication and collaboration with the help of an MKO. MKOs here not just refer to a teacher in a classroom but can be mentors, peers, books, technology, environment, etc. Therefore, analysing LLMs as one of the MKOs in providing support and assistance to learners in this study can expose their affordances in the learning process. This is particularly beneficial in the context where learners have different learning

Connectivism	Posthumanism
Diversity of Opinions	Multiplicity; Inclusivity
Connecting Nodes and Information Sources	Relationality; Multiplicity
Non-Human Appliances	Human-Nonhuman Entanglement; Non-Binary; Assemblages; Hybridity
Connecting between Fields, Ideas & Concepts	Non-Linearity; Non-Hierarchical; Heterogeneity

Fig. 2 Connections between connectivism and posthumanism

needs and styles and may require additional assistance. This study also explores the various MKOs such as LLMs, peers, and researchers, and their connected mediation in the learning process through the intervention of the study. Similarly, from the perspective of connectivism, which underscores the interconnectedness of humans and technology, this study investigates new ways of learning that are influenced by and accommodate LLMs for an inclusive education. Therefore, this study is built on the theory of connectivism and Vygotsky's ZPD model to explore LLMs and AI chatbots in an ESP classroom and illustrate the networked learning essential for an inclusive education in posthuman times.

5 Methodology

5.1 Design

This study aims to document the experience, perceptions and reflections of the learners by adopting a case study methodology. The case study relies on thick descriptions to gather in-depth and detailed information, adding multiple dimensions to the research (Zainal, 2007), which also aligns with the theory of posthumanism and connectivism. These theories acknowledge the diversity of opinions and encourage the exploration of non-linear connections and relations between human and non-human. The comprehensive qualitative data produced through the case study will explain the complexities of the learning process, which is networked, non-linear, hybrid, multiple and relational. Therefore, this case study documents a specific teaching–learning episode involving LLMs, which warrants further pedagogical considerations.

The study was ethically approved by the host university, and the participants agreed to voluntarily participate in the study after being informed of the purpose of the study, the duration, and the procedures, which involved screen-recording their laptops, audio-recording the interviews and discussions, and taking pictures for documentation.

5.2 Participants

Engineering students from an institute of national importance were the participants of this case study. Twenty students from first-year Mechanical Engineering were chosen for the study among the thirty volunteers. These twenty participants were selected as per their explorations and considerable use of LLMs for both personal and professional use. To enhance the relevance of the data (Bock & Sergeant, 2002), a purposive sampling method was employed to select the participants. The initial screening of the participants was carried out based on their perspectives on and familiarity with the LLMs, which they demonstrated through their answers to the question "Produce a report on the impact of Chat GPT in education by critically assessing the potential advantages and disadvantages that may arise" in their end-semester examination. The criteria for selection included their ability to articulate the advantages and challenges of using LLMs and their demonstrated interest

in AI-assisted learning. Forty-five participants were screened through this process, out of which thirty volunteered to participate in the study. Finally, twenty students were selected based on the background discussion, which was conducted to further assess their familiarity with LLMs and their prior experiences with AI-driven tools. It was also based on their engagement and expressed willingness to critically reflect on AI-assisted learning. The participants and setting of the study were chosen primarily out of convenience and to ensure efficacy, as both the first author (also the researcher) and the second author are affiliated with the same institute. The chosen sample for the study is representative of a diverse group of learners as the institute attracts students from various regions, linguistic backgrounds and academic disciplines across the country. This diversity makes the study suitable for examining LLMs in inclusive education. The participants included thirteen males and seven females belonging to the age group of 17–19.

Additionally, the focus of this case study is on the perceptions and experiences of the learners in using LLMs in the educational setting instead of analysing specific behavioural outcomes. While socio-cultural and economic backgrounds may influence learning experiences in broader contexts, this study did not explicitly analyse their impact. However, prior research suggests that learners' engagement with LLMs is primarily shaped by their digital literacy and familiarity with AI tools (Bender, 2024). Therefore, there is scope for future research that could explore how demographic variables mediate LLM interactions.

5.3 Setting

All the engineering students at the institute are offered 'English for Communication' as a compulsory course in the first year of their engineering program. This course, which aims to develop the learners' professional communication skills, also strives to create a responsible and inclusive environment for them where they can exercise autonomy and critical thinking abilities. The course caters to building their content knowledge through inquiry-based learning along with a focus on the LSRW skills. Hence, the study is relevant to the learners as it concerns the development of

Instruments	Coded as
Audio-recorded Background Discussions	BD
Screen Recordings	SR
Learners' Composition	LC
Semi-Structured Interviews	SSI
Researcher's Diary	RD

Fig. 3 Data collection instruments

language skills as well as the content knowledge of the learners through the intervention of the LLMs.

5.4 Instruments

This study used the following instruments for data collection, as shown in Fig. 3.

The audio-recorded discussions were an attempt to capture the participants' spontaneous responses as they worked, the challenges they faced and strategies they used. Similarly, the participants' interactions with LLMs were gathered through screen-recording while they worked on the assigned task. The recorded data helped in providing insights into their engagement patterns, tool dependency and connected learning. The semi-structured interviews were conducted at the end of the study with each participant to understand the overall learning experience. The questions for the interview included how LLMs influenced their learning and writing processes, how they approached their task, and what method they followed. Additionally, the reflection reports submitted by the participants were written reflections detailing specific aspects of their interactions with LLMs, which included identifying biases, credibility of the information provided, and redundancy. Finally, the learners' compositions were used to examine their writing proficiency and their ability to exhibit their content knowledge effectively.

5.5 Procedure

The study was conducted in 2024 for six weeks and incorporated three phases: background study, intervention and interviews.

5.5.1 Background study

In the initial phase, a background study was conducted to understand the learners' familiarity and already-formed perspectives about LLMs. These semi-formal preliminary discussions were audio-recorded for further deliberations. Additionally, during this session, the learners' proficiency in interacting with LLMs and employing pertinent keywords and phrases to retrieve the relevant information was also explored. Further, a Google form was circulated to gather the participant's details as a part of the background study.

5.5.2 Intervention

The intervention of the study required the learners to do a project in pairs. They were given a prompt in the initial stage of the intervention- "Choose a theme to work under, which falls at the intersection of sustainability and engineering". Therefore, the learners in pairs chose 'Design for Sustainability' and 'Energy Efficiency and Resource Conservation' as themes to work under. The project comprised a structured framework with learners brainstorming ideas individually and collaboratively

in pairs and generating potential directions of inquiry. Then, the learners used LLMs as the primary means of further exploration into the subject matter, using digital resources to improve their understanding of the subject. During this exploration, the learners analyzed the content produced by LLMs, examined the acquired information, used various other online platforms to verify and learn more about them, identified patterns and made meaningful connections from the various sources of information. Throughout the process, learners also peer-reviewed each other's trajectories, exchanged feedback, collectively reflected on the ideas, and discussed them with the researcher as they deemed fit. Consequently, the laptops of the learners were screen-recorded to map the learning process by analyzing the kinds of prompts, keywords, and the various sources used by the learners during the project. Below is Fig. 4, which shows a visual representation of networked learning upon scanning. The screenshots are representative of the numerous trajectories advancing throughout the intervention.

5.5.3 Learner's composition and interviews

In the final phase of the study, the learners produced a report/review article on Design and Sustainability and Energy Efficiency and Resource Conservation. The outcome of the project was to produce a thorough report, as report writing within the purview of the 'English for Communication' course curriculum was essential. This task was strategically created to equip the learners with the skills and abilities requisite for crafting comprehensive and professional reports. Following this, one-on-one interviews were conducted to document the takeaways, experiences, and challenges of the learners throughout the study. The audio recordings of the interviews were transcribed for further analysis. The front page of the learners' composition after the completion of the project is available in the Appendix.

Fig. 4 Video representing connected learning

6 Data analysis

The collected data through audio recordings were transcribed verbatim and reviewed. The screen-recordings were analysed to look for their learning patterns, tool dependency and connected learning. To analyse the data thematically, a combination of inductive and deductive coding was used where some predefined codes were applied based on the existing literature concerning LLMs and the aim of this study, such as digital literacy, ethical issues, and biases; other emergent codes were identified during the analysis, such as collaborative learning and perceptions of AI. Consequently, these coded data were grouped within broader themes, connecting with the two theories, which are discussed further to elucidate the spectrum of potential trajectories that may help in exploring and answering the research questions. Additionally, the reliability of the data analysis was ensured by having the second author review the data analysis.

Therefore, all the themes that emerged during the analysis have been categorised and presented under two major subheadings (6.1 & 6.2), each corresponding directly to the key theoretical frameworks used in this study. Specifically, these two subheadings reflect the conceptual lens of Vygotsky's More Knowledgeable Other (MKO) and Connectivism, framing the discussion around LLMs as MKOs and LLMs as promoters of networked learning. Finally, the analyses within these theoretical themes are summarised in the findings section.

6.1 LLMs as MKO in the learning assemblage

More Knowledgeable Other (MKO) leads the learners from their current zone of development to the zone of proximal development (ZPD) through scaffolding. The ZPD model originates from Vygotsky's sociocultural theory (Vygotsky, 1987, 1978), which refers to a space where the learner is involved in tasks that require guidance from an expert/MKO. This would help the learner improve their potentialities and expand their current zone of development. MKOs, traditionally perceived as teachers/mentors, can also be other human-nonhuman aspects such as the internet, books, peers, environment, etc. In this study, LLMs also worked as MKOs, enabling the learners to expand their current zone of learning by facilitating personalised learning, encouraging collaboration and improving their English language skills, which are discussed further.

6.1.1 Facilitating personalised learning

Personalised learning enables the learners to receive, access content and learn concepts that are tailored to their specific needs (Wang, 2023). However, in the tremendously entangled learning assemblage, all the factors collaboratively influence the content and structure of the learning environment with their varying degrees of agency. In this regard, LLMs serve as dynamic and personalised spaces that prompt learners to think, act and interact. For instance, the learners shared that they use LLMs to simplify any complex concept while learning, using prompts such as '*Can*

you explain the concept of thermodynamics as if you were explaining to a 12-year-old child?' and *'What is feminism in layman's terms?' (RD).* The learners also shared that they use LLMs to complete their assignments and get feedback from them in terms of language and structure to produce a '*polished academic essay*'. It was noted that LLMs facilitate personalised learning by enabling the learners to revise their writing based on its feedback. For instance, one of the participants mentioned, *'I realised I could ask the tool to help me with adjusting the tone of my writing, which was something I struggled with before.'* Therefore, LLMs can take up the role of an MKO in a learning assemblage by helping the learners with scaffolding and expanding their current developmental zones, as they answer questions with detailed information, provide relevant feedback, aid the learners with their writing skills, and also keep them motivated. This personalised learning space promotes inclusivity in the classroom as LLMs as a medium can serve as an MKO to learners of any level (Fig. 5).

These results are not the outcome of a simple cause-effect relationship between humans and LLMs alone. From a posthuman perspective, it becomes imperative to look at all the possible factors contributing to the learning process. Learning, therefore, should be understood as "complex relationships among learners, teachers, content, and technology within particular social and cultural contexts" (Kern, 2006, p. 201), enabling collaboration.

6.1.2 Encouraging collaborative learning

Though the intervention required the learners to work in pairs for their project, the observation and results of the project gave significant insights concerning the importance of collaboration and having multiple sources of MKOs in learning. Collaboration in this context occurred between learner and LLMs, learner and peers, and learner and researcher, where LLMs, peers and the researcher were the MKOs, facilitating the learning process. While LLMs, with their human-like interaction, can collaborate with learners on many levels, such as by giving relevant information and feedback and assisting in generating ideas, they may also be a cause for distraction with their excessive source of information. This creates a space for connected collaboration where every factor in the learning assemblage contributes to the learning process (Fig. 6).

Transcript

"For example, I might not be great at coding, but I might not be a good student of chemistry subject. So, the pace of learning is different for me in different subjects. And I don't think the teacher would be able to teach in such a way that it matches the level of every student in the class. And sometimes, because of my insecurities… I might not be comfortable asking questions to clarify my doubts in a classroom… in front of all my friends. So, Language models can help me in a personalised way. Let's say I am having difficulty with a concept in chemistry, I would use the prompt- "Explain this to me with examples like how you would explain it to a 10-year-old" and the Language model would break it down for me as per my requirement. I can't ask the same thing to my teacher" (BD)

Fig. 5 LLMs working as MKOs

Transcript

Kabir just said that Saba keeps pulling him back from getting distracted. When there are so many websites, so much content, and technology that includes not just laptops but also mobile phones, there is a high possibility of getting lost or digressing from their objectives. Collaborative learning in this situation also helps the learners to work together and keeping each other from digressing. Meanwhile, they are also asking a lot of questions to the teacher-researcher regarding the available resources, how to effectively read a research article, how to find the research gap and what methods to follow. This is a connective network of learning where students, teachers and the technology come together and facilitate the learning process (RD) (Pseudonyms are used here)

Researcher: "How was your experience working as a pair?"
Learner: "It was good. She had nice valuable points that I have included in the paper. She designed some prompts that were… What should I say… Necessary for getting the vital output that I required from AI. Peer learning was great. It was important because learning can get boring sometimes when you are on your own…" (SSI)

Fig. 6 Collaboration among learners through the intervention of LLMs

Similarly, teachers as MKOs can guide the learners in mastering a subject or a concept but may be of limited help if it is outside the scope of their expertise. However, they could give inputs based on their lived experiences that would help the learners reach other sources and ways to attain their goals. This brings us to the argument that posthumanism posits, according to which, everything is relational in a learning assemblage where every factor has its own agency to exert through its relation to the others (Lenters & McDermott, 2020). This clears the most debated discussion of whether AI and technology would replace teachers in education. Every factor in a learning assemblage has its role to play with varying degrees of agency depending on a particular social and cultural context. The contribution of LLMs and technology is expected to be higher in the learning process of a student who is taking online courses. Whereas a student pursuing a course in an institution might have various other factors with their own contextual and relational agencies contributing to her/his learning. Either way, the intervention of LLMs in the learning assemblage tremendously impacts the learners' language proficiency.

6.1.3 Improving English language skills

The intervention enabled the learners to enhance their English language skills with the help of MKOs involved in the study (LLMs, peers and the researcher). It required them to communicate efficiently to discuss and share insights with their peer and work on their presentation skills as they had to present the ideas and the progress to the researcher (Fig. 7). They also worked on their writing skills by getting feedback from the researcher as well as LLMs (MKOs) as they had to produce a thorough report by the end of the project. Report writing tasks within the purview of the 'English for Communication' course curriculum were essential to equip the learners with the skills and abilities requisite for crafting comprehensive and professional

Transcript
"I would say… this study gave me one more opportunity to work on my presentation skills. I sometimes feel that I do not present my ideas as clearly… it sounds in my head. The more I had to discuss and present my ideas on complex engineering topics to you, who is from a different field, I felt more confident about how I present and convey my idea" (SSI)
Learner: "This definitely helped us with academic writing and research. I have written reports before, but those were just a summary of a meeting or… probably an event. This was a great learning experience for me and I think it would be really helpful for me… in my final year to write actual research papers." *Researcher: "What are the factors that you think helped you with your writing?"* *Learner: "I used ChatGPT to get suggestions on my phrasing and writing. I also used Gemini to… you know… make connections between the contents of my report so that it looks neat and coherent."* *Researcher: "Can you elaborate on your research skills? How do you think they improved?"* *Learner: "To be frank, I wasn't aware of the databases which had so many research papers. But my teammate knew some and you also introduced us to sites like… ah…* *Libgen and Google Scholar which was really helpful. It was also overwhelming in the beginning when I saw so much work done in the field... I didn't know where to look at. But I think working as a pair was good since we were doing this for the first time and… yeah… I understood how important it is for the content to be credible. So, overall, I would say… it was an intense learning experience." (SSI)*

Fig. 7 Learners' self-reflection on their improvement in English language skills

reports. Through the project, they learnt how to write professional and academic reports. Among twenty participants, seventeen of them mentioned that using LLMs helped in improving their academic writing skills. Learners also shared that they developed research skills through this intervention as they explored new academic avenues and systematic methods to write the review/report. Therefore, adhering to the established standards of formal report writing, the learners honed their skills concerning synthesising the information and coherently organising the content. This study's intervention served as a platform to develop their research skills and understand the complex nature of learning by acknowledging the role each factor had in their learning process.

6.2 LLMs as promoters of networked learning

From the collected data, the use of diverse prompts was observed while analysing the screen recordings. It was found that the learners used LLMs for various purposes such as understanding concepts, knowing the current trends, exploring future scopes, learning vocabulary, making coherent connections between heterogeneous themes, structuring the essay, and many others. The learners used the preliminary information gathered from LLMs to explore more (Fig. 8) by using other online

Transcript

"When you are not very sure of what you are doing, you are researching a particular topic, in those cases, we can just use Chat GPT and Language models as a starting point and if something clicks upon, we can take it forward and work on that…" (SSI)

Fig. 8 Learner sharing the usefulness of LLMs in gathering information

resources such as Google web search, Quora, Wikipedia, YouTube, Blog Posts, Google Scholar, NoteGPT, and various educational databases.

For instance, one of the pairs used Gemini to learn Energy Efficiency and Resource Conservation individually; they then discussed their viewpoints, established a common ground and made use of Google Docs, which can be accessed by both. After narrowing down the elements they were focussing on, they explored other resources to gather information about the same, carefully analysed the information, summarised the content and recorded it on their Google Docs. Below are the figures (Figs. 9, 10, 11, 12, 13, and 14) displaying a small segment of their engagement which is representative.

The learners were exposed to diverse opinions that came from the technological resources, their peer, the researcher, and their prior knowledge. Through the intervention, they connected various sources of information, critically analysed them, and made further connections between and across fields, ideas and concepts. For instance, they were able to draw connections between superhero movies such as Batman and their topic, which involved

Fig. 9 Initial discussion among the learners

Fig. 10 Using LLM (ChatGPT) to initiate the dialogue and understand the concepts

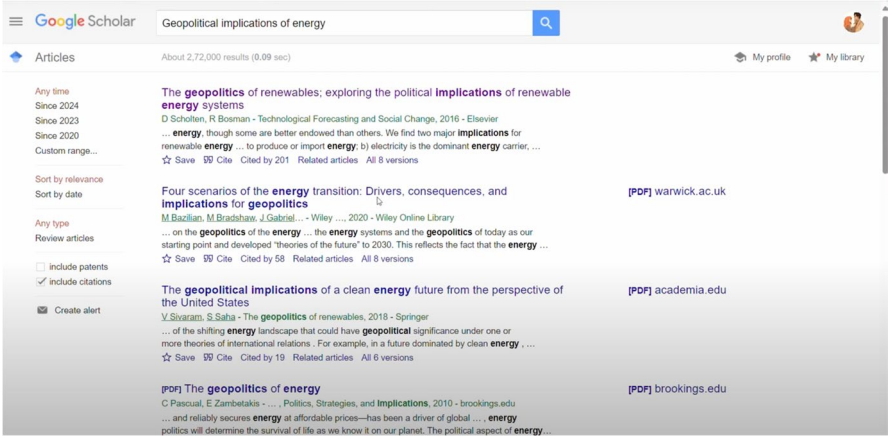


Fig. 11 Using Google Scholar to access scholarly articles to gather critical insights on the ongoing discussion

discussions on metals, data, and climate change. One of the learners made connections that depicted the need for continual learning as he noted down a start-up idea on his mobile phone while he was reading an article and expressed his keen interest in learning more about lithium. Therefore, while it is easy to get distracted due to the plethora of information and other exciting features on the internet, the learners displayed the ability to make

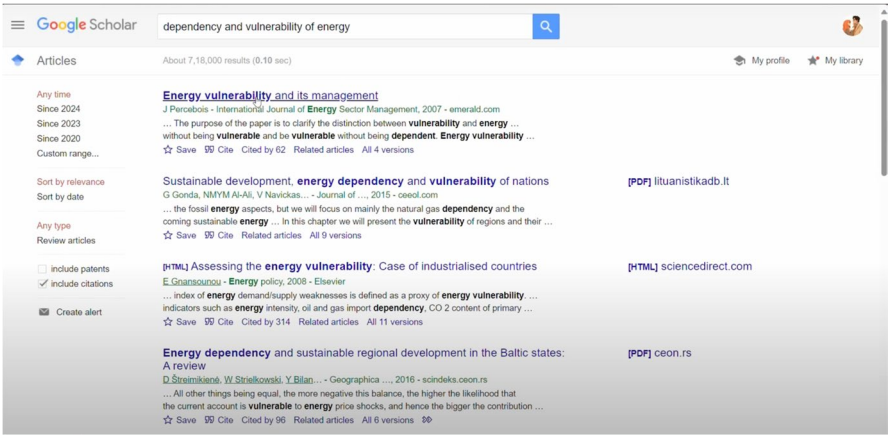


Fig. 12 Accessing research articles to know more about 'Dependency and Vulnerability of Energy', which was briefly mentioned by the LLM as one of the key considerations

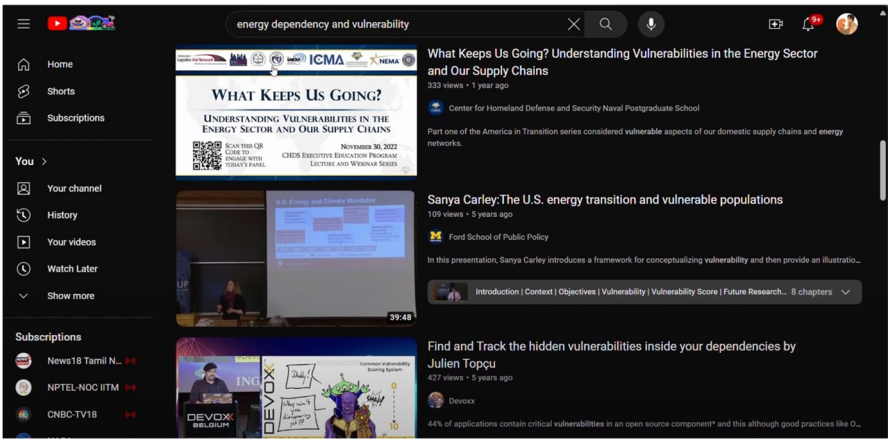


Fig. 13 Accessing YouTube videos for simple and creative engagement regarding the topic

decisions on what to pay attention to and how to go forward with the group project. Hence, LLMs in the learning assemblage can promote networked learning, which adheres to the principles of connectivism. Below is a diagram visually depicting the possible connections that were made in the learning process (Fig. 15).

Such a networked learning experience enabled inquiry-based learning, fostered digital literacy and critical thinking, and promoted academic responsibility among the learners, which is discussed further.

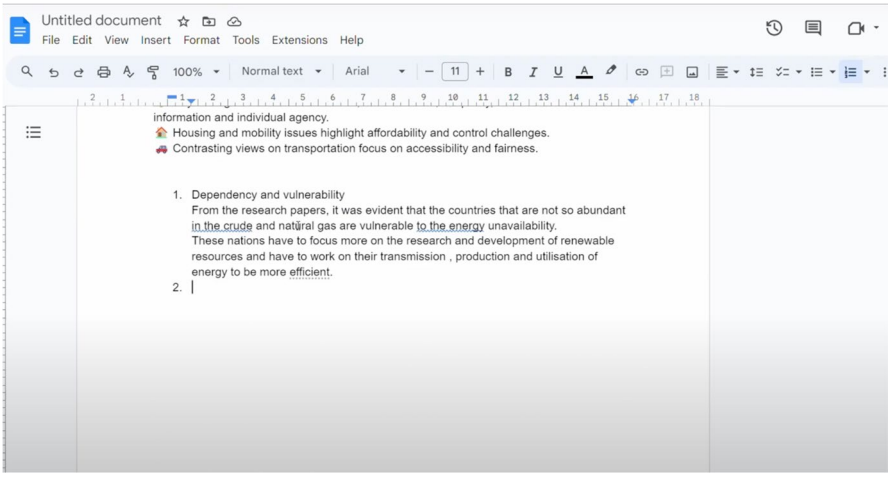


Fig. 14 Noting down the key takeaways after connecting various sources of information

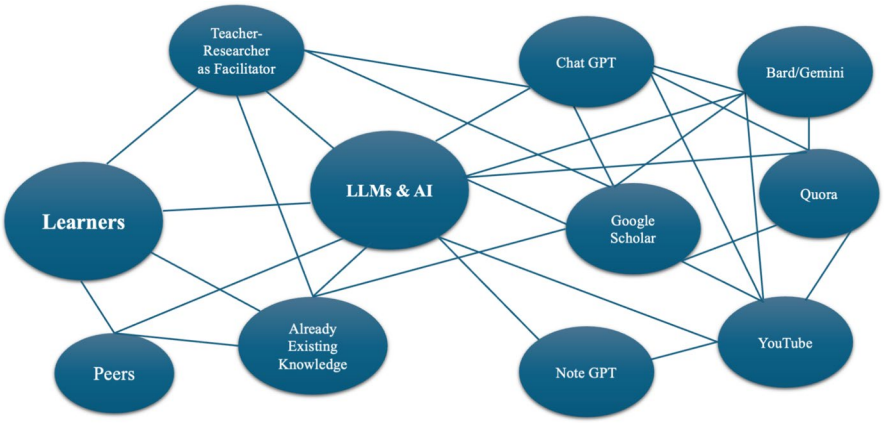


Fig. 15 Networked learning through LLMs

6.2.1 Facilitation of inquiry-based learning

The intervention of the study equipped the learners to explore different perspectives, retrieve relevant information, gather evidence by using other reliable resources, and formulate research questions to guide their inquiry. Learners were able to reflect on their inquiry process on individual and collaborative levels and synthesise their findings as a review/report. They also expressed that, in the initial phase of the project, when they were not sure of what to work on, using LLMs was helpful as a starting point to explore potential areas of inquiry. This was also accompanied by their keen interest in the concepts that they were learning in their Energy and Environment Engineering class (Fig. 16).

Transcript
"But then, when you are not very sure of what you are doing, you are researching a particular topic, in those cases, we can just use Chat GPT and Language models as a starting point and if something clicks upon, we can take it forward and work on that" (BD)
Researcher: "How did you choose this topic?" *Learner: "So, we had a discussion in our ENIR classes… So, it was planned out of the thought that I should be related to the class or something.. When my teammate and I were discussing about something.. It was relatable at the time… So, we chose a topic that was slightly controversial… Slightly has implications in politics. And everything. So, the energy crisis is. What should I say… We have a little bit of exposure to it from ENIR classes, and Through this project, I learnt a lot about energy crises… Like the political play going behind that… The power dynamics... Strategies used by different nations" (SSI)*

Fig. 16 Kindling inquiry-based learning through LLMs

6.2.2 Promoting networked learning and digital literacy

This intervention with LLMs promoted networked learning where the learners made connections across fields, ideas and concepts (Siemens, 2005a, b). They learnt from various sources, which include technology, peers, environment and the researcher. It was also observed that the learners were referring to films to understand the concepts better, making notes about specific concepts that have the potential to be start-up ideas (Fig. 17). The intervention also enabled the learners to effectively navigate digital spaces and improve their media literacy as they analysed various forms of media, including texts, audio, images and videos (Hockly, 2023). Through collaboration and networked learning, the learners had the opportunity to analyse various information sources, making inferences with respect to their credibility and limitations (Adeshola & Adepoju, 2023).

Transcript
Kabir also was noting down something on his mobile phone as he was reading an article on his laptop. When I asked him what it was, he showed me and, on the screen, there were pointers which were basically start-up ideas. When I asked to elaborate on what he noted now from the article, he mentioned lithium and how it can become a great market in India in the future. Therefore, learning in such ways will not only cater to the basic requirements of the course and completing the assignments, but it will spread out as a web with much more scope, knowledge and ideas. (RD)
They were also making connections to the Batman film and attempting to reason the Marvel shown in the film. The discussion involved talking about metals, reactions, lasers, lightning, projection, thunderstorms, data, climate change, etc. (RD)

Fig. 17 Depicting networked learning from learners' experiences

For instance, fourteen participants among the twenty mentioned that privacy was a major concern while accessing various websites as they were required to log in or provide their data; they also noted that the information provided by LLMs seemed superficial and biased at some levels. The discussions also indicated that more than ten participants expressed that they felt frustrated when AI generates misleading or low-quality content, which makes its credibility questionable. Similarly, twelve participants among all affirmed that they felt both empowered and anxious while using AI for learning. Such an experience of incorporating LLMs in the learning assemblage enabled the learners to understand the social and emotional dimensions of utilising and comprehending them (Zhao et al., 2021) where they shared concerns regarding the possible cognitive and emotional dependence on AI, frustration and ethical dissonance caused by redundancy, and also the positive social aspects including the possibilities of peer interactions and collaborative working strategies.

6.2.3 Fostering critical thinking skills

The learners were able to analyse and evaluate the information produced by LLMs and synthesise all the relevant details obtained from various sources of information such as research articles, YouTube, Blog Posts, etc. (Kasneci et al., 2023). They had discussions with their peers to confirm the reliability of information produced by LLMs by applying their prior knowledge and experience in the field (Fig. 18). This experience enabled the learners to become active, discerning participants rather than passive recipients of AI-generated information who were able to interpret AI's feedback critically and evaluate the accuracy of information with reliable sources such as research articles as well as discussions with their peers and the facilitator.

Transcript

Researcher: "Was it a better idea to read research papers? Or was it a waste of time as you could simply ask the Language Models?"
Learner: "Based on the topic, I would say…reading the research papers was a good point of view… I guess… because who knows? The AI can be lenient in some ways. Because we still thought… umm… AI just published X country everywhere. We don't know why, but every article or response is related to energy… X country had a minor presence" (SSI)

Researcher: Did you use the content produced by LLMs directly in your report? How did you go about writing your article?
Learner: We did use the content from Gemini. But not as it is. It was used to generate ideas.. and Me along with my peer… we individually read more about it and saw videos as well. Well… there was one instance where I found a blog post which completely denied what ChatGPT said. So… we were also discussing how… it can all be false sometimes… although it is a very useful tool… yeah…
Researcher: So, how did you analyse the content and come to a conclusion about what to write in your report?
Learner: We obviously had a discussion about it… then we tried to learn more. I think after reading from other sources, and also trying to apply what we learnt in our ENIR classes… It was easy to figure what we wanted to write.

Fig. 18 Critical thinking and LLMs

6.2.4 Promotion of academic responsibility

With the learner's prior experience of using LLMs, interference of the teacher-researcher and through this intervention, the learners were able to reflect on their digital competencies (Hockly, 2023) and collectively recognize the capabilities and shortcomings of LLMs with their peers and the researcher. Although some participants shared in the initial stages of the study that they found AI and technological tools to be fascinating, through this study, they were able to recognise the social and ethical dimensions of using LLMs. Working in pairs and collaborating with the facilitator enabled transparency while working on the task, which led to identifying and understanding the potential risks, biases, issues with credibility, and quality of the content being generated by LLMs. Five participants were initially of the opinion that AI can replace the traditional classroom practices and even compromise on the role a teacher takes. However, their perspectives changed as they realised its effectiveness when used responsibly with more awareness. The learners were able to locate potential biases by operationalising their critical thinking skills. They used LLMs responsibly given the ethical concerns they may pose, which was reviewed elaborately during background discussion. They were also able to analyse the role of every element in the learning process (Fig. 19).

Transcript
Researcher: "Was it a better idea to read research papers? Or was it a waste of time as you could simply ask the Language Models?" *Learner: "Based on the topic, I would say…reading the research papers was a good point of view… I guess… because who knows? The AI can be lenient in some ways. Because we still thought… umm… AI just published X country everywhere. We don't know why, but every article or response related to energy… X country had a minor presence…" (SSI)*
Researcher: "Do you think AI is enough for you to learn? Or Do you still think you need a classroom, your peers and teachers?" *Learner: "I don't think AI will be enough. It is bounded by its political rules, It is bounded by the developer and the various criteria, So, sometimes I am not getting what I'm exactly looking for. I can ask a teacher to explain a concept from multiple points of view based on his expertise and experience in career and life in general.. but from an AI, I don't think it is possible." (SSI)*
Learner: Using AI was a great option before this research project… like on a day-to-day learning basis… but now I think that it would be a valuable addition to the learning process. I would recommend AI tools to my peers as an addition and not as a sole substitute for teachers. Like… it is not a core of a team, but a good part of a team. (SSI)

Fig. 19 Responsible use of LLMs

7 Findings

7.1 How do LLMs and AI chatbots support learners and educators in creating inclusive and academically responsible learning environments in an ESP classroom?

The data analysis demonstrated that LLMs as an intervention in the learning assemblage provided personalised learning to learners with different learning capacities and needs. In a classroom with a large number of students, LLMs can help ensure that all the learners who are familiar with technology can access the learning aids they need to succeed. This can reduce the stigma associated with learning differences and capabilities. Therefore, by providing personalised learning support, learners are motivated to feel confident and included in the class, thereby ensuring inclusivity. Consequently, with the exposure to networked learning, the learners explored various tenets of digital technology and AI in the learning process, which improved their digital literacy skills. However, this opened avenues for discussions that concerned the ethical consequences in the field of education.

It has been argued that the integration of AI and LLMs in education can lead to many ethical issues, disrupting the systematic functioning of the education system. The extensive use of AI and LLMs may lead to biases as the data produced by those models might not be credible. Studies have reported that students misuse AI and LLMs for unethical practices during examinations (Kohnke et al., 2023). One of the learners exposed that he, along with his classmates, uses ChatGPT and Gemini to complete their assignments effortlessly (Cotton et al., 2024). Some disagreed and stated the lack of awareness to be a cause for its misuse. They also shared that some of their peers are addicted to Gemini and use it to the extent that their autonomy and thinking capacities can diminish (Fig. 20).

However, with the help of rigorous discussions and intervention, a perceptional change was witnessed among the learners concerning the responsible use of LLMs in the learning assemblage. One of the learners shared that, *'I think we can't completely rely on LLMs for learning. If we use it responsibly alongside the teachers, it would be amazing' (SSI).* Therefore, informed use of LLMs in a classroom can lead to the promotion of social and academic responsibility as a learner. The learners also shared that LLMs cannot be completely relied on as their responses might be problematic, vague and erroneous (Fig. 21). Therefore, using LLMs meaningfully and

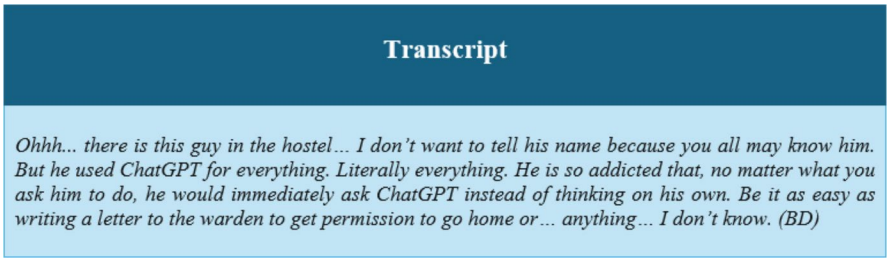


Fig. 20 The ethical concerns of using LLMs

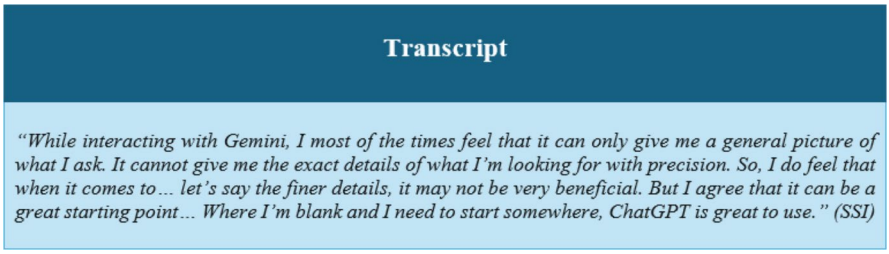


Fig. 21 Learner expressing the unreliability of LLMs

responsibly with an awareness of their potential and drawbacks can reduce the ethical and social consequences. This can be made possible by accommodating LLMs in classrooms 'with' the learners, alongside an MKO, similar to the intervention of this study.

A perceptional change concerning the ethics of using LLMs in classrooms facilitated academic responsibility and integrity among the learners. The interference of the researcher through the intervention enabled the learners to reflect on their digital competencies (Hockly, 2023) and collectively recognise the potential and shortcomings of LLMs for maximum results. This also facilitated the learners to scrutinise the credibility of the information provided by the LLMs by operationalising their critical thinking abilities. Therefore, such interventions involving a collaborative endeavour involving teachers and learners together can promote academic responsibility and the responsible use of AI and LLMs in the learning process.

7.2 What are the pedagogical implications of accommodating LLMs and AI Chatbots in developing the content knowledge of the learners?

The evidence from the data analysis suggested that accommodating LLMs and AI chatbots in classrooms to develop the content knowledge of the learners can facilitate inquiry-based learning, where the learners explore various perspectives, analyse the credibility of the information and investigate them from diverse learning avenues. This collaborative project/intervention fostered collaboration among the learners, the learner and LLMs, and the learners and the researcher. The learners also mentioned that such collaborative learning enabled them to approach any idea from diverse perspectives as they worked in pairs, reduced distractions due to a plethora of information and various sources online and improved their ability to be team players. This collaborative learning encouraged them to analyse and evaluate each other's trajectories and the information produced by LLMs by operationalising their critical thinking skills. The intervention also promoted digital literacy and networked learning among the learners as they effectively explored digital spaces and developed their media literacy by analysing various forms of media, including images, texts, audio and videos.

Consequently, the data analysis revealed that the use of LLMs in the classroom directly impacted the English language skills of the learners, as the intervention required them to discuss insights concerning their project and work on their presentation skills, which are required for effective communication. Similarly, the collaborative feedback and assistance provided by LLMs and the researcher contributed to the improvement in their writing skills as evidenced by their thorough project reports. The information presented in their submissions met the academic standards and was coherently organised.

8 Discussion

In posthuman times, where AI and technology are exerting their dominance over the education system, it becomes imperative to devise ways to tackle the current situation. Networked learning from the perspective of connectivism would acknowledge the complexities involved in the learning process (Omodan, 2023) and can suggest ways to accommodate AI and LLMs without disrupting the principles of education. In such an attempt, this study has contributed to the literature by documenting a posthumanist-connectivist intervention and its implications in an English for Specific Purposes classroom. It suggests that LLMs can take up the role of an MKO and aid the learners with scaffolding and expanding their current developmental zones (Stojanov, 2023). It illustrates decentralised learning that emphasises the importance of networks (Downes, 2012). It affirms that every factor (human, non-human) contributes to the learning process through their relational agencies within a specific social and cultural context (Lenters & McDermott, 2020). Concerning the facilitation of personalised learning, this study confirms the assertions made by Kasneci et al. (2023) and Tlili et al. (2023). Similarly, this study affirms that using LLMs through a connectivist approach can facilitate collaboration (Alam, 2023) and critical thinking skills (Kasneci et al., 2023). It also improved English language skills (Allagui, 2023; Fitria, 2023), such as writing and communication. While Long and Magerko (2020) contend that learners will require digital/AI literacy skills in education, this study reports the expansion of digital/AI literacy skills through collaboration and details the networked learning fostered by digital literacy.

However, with the growing interest in LLMs in education, there are also many ethical concerns with regard to academic integrity as LLMs are referred to as 'high-tech plagiarism' (Stewart, 2023). As a reaction to the enhanced risk for unethical practices, many universities and institutions expressed their willingness to revert to the traditional assessment formats involving pen and paper (Tlili et al., 2023). To address this issue, many have emphasised in their study the importance of reflecting on the implications of LLMs 'with' learners (Farrokhnia et al., 2023; Supiano, 2023). This is because there is a gap between the teachers' expectations and learners' lived realities. While the teachers expect the learners to show academic integrity, the learners choose to use LLMs due to the convenience they provide with their academic tasks. Therefore, encouraging learners to work with LLMs alongside a more knowledgeable human, preferably a teacher, and engaging them in discussions about ethical concerns, academic integrity, principles of education and limitations of LLMs can help in collectively and responsibly adapting to such technological innovations (Abramson, 2023). On that account, this study helps in bridging the

gap between learners and teachers as the intervention enabled the researcher and the learners to collectively reflect on its limitations and possible ways of accommodating them in the learning assemblage with constructive pedagogical implications. To ensure the responsible use of AI tools, educators can create awareness of AI's limitations, including bias and potential misinformation. They can encourage learners to use LLMs for learning enhancement rather than generating content for assignments, guide learners to evaluate AI-generated content critically by providing examples and case studies and educate them about data privacy.

Given the number of participants, the findings of the study are constrained by limitations and are contingent upon a specific context. As a consequence, the applicability of the study's inferences may not be valid for learners of diverse levels, especially those who lack digital literacy (Kohnke et al., 2023). Alam (2023) also mentions the need for digital literacy, as the connectivist approach relies on technology and digital spaces. Kohnke et al. (2023) also assert that there are specific forms of digital competence required to use LLMs in a classroom, including technological proficiency, pedagogical compatibility and social awareness, which is established in this study. Therefore, familiarisation of AI and LLMs to learners and teachers becomes imperative to navigate the rapid technological advancements.

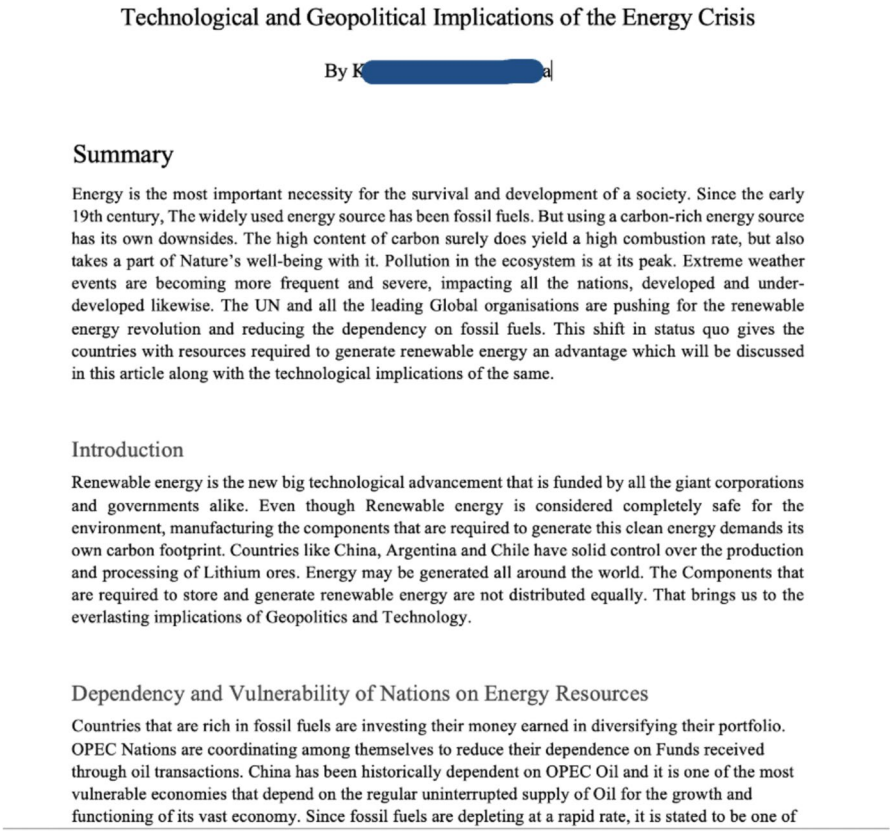
9 Conclusion

The study discussed the possibility of new teaching and learning methods in an ESP classroom that incorporate AI and LLMs from the perspective of Vygotsky's MKO and posthuman connectivist approach. This attempt illustrated the non-linear and networked learning involving human, non-human and technological resources in the learning assemblage. It explored the efficacy of LLMs as pedagogical tools in an ESP classroom. The results of the study detailed the pedagogical implications in developing the content knowledge of the learners and asserted that the intervention facilitated inquiry-based learning, critical thinking, communication, report writing, digital literacy and research skills. The findings also affirmed that the rational use of LLMs can create inclusive and academically responsible learning environments.

Despite the rising concerns regarding academic integrity and ethical issues, the study suggested that educationists and learners should find ways to collectively work and accommodate LLMs in classrooms. The responsible use of LLMs can be fostered by reflecting on their potential and limitations along 'with' learners, which was attempted in this study. Therefore, the study provides scope for the exploration of LLMs and creative interventions in educational practices. Further research on LLMs can adopt a mixed-method study to demonstrate many other potential trajectories in English language education. Future studies could also explore the long-term impact of LLM integration on learners' writing autonomy and metacognitive development. Comparative studies across different educational contexts could provide deeper insights into the scalability of AI-assisted learning. Additionally, empirical investigations into educators' perspectives on LLMs as a pedagogical tool could further enhance our understanding of how they reshape teaching methodologies.

Appendix

Learner's composition examples



Technological and Geopolitical Implications of the Energy Crisis

By K[redacted]a

Summary

Energy is the most important necessity for the survival and development of a society. Since the early 19th century, The widely used energy source has been fossil fuels. But using a carbon-rich energy source has its own downsides. The high content of carbon surely does yield a high combustion rate, but also takes a part of Nature's well-being with it. Pollution in the ecosystem is at its peak. Extreme weather events are becoming more frequent and severe, impacting all the nations, developed and under-developed likewise. The UN and all the leading Global organisations are pushing for the renewable energy revolution and reducing the dependency on fossil fuels. This shift in status quo gives the countries with resources required to generate renewable energy an advantage which will be discussed in this article along with the technological implications of the same.

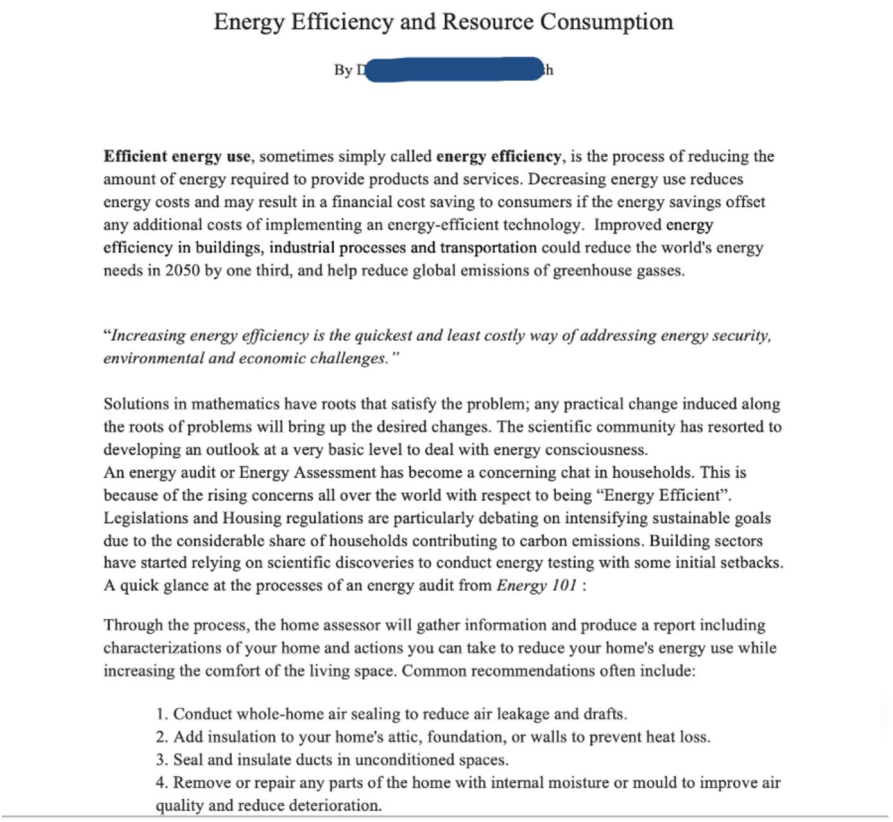
Introduction

Renewable energy is the new big technological advancement that is funded by all the giant corporations and governments alike. Even though Renewable energy is considered completely safe for the environment, manufacturing the components that are required to generate this clean energy demands its own carbon footprint. Countries like China, Argentina and Chile have solid control over the production and processing of Lithium ores. Energy may be generated all around the world. The Components that are required to store and generate renewable energy are not distributed equally. That brings us to the everlasting implications of Geopolitics and Technology.

Dependency and Vulnerability of Nations on Energy Resources

Countries that are rich in fossil fuels are investing their money earned in diversifying their portfolio. OPEC Nations are coordinating among themselves to reduce their dependence on Funds received through oil transactions. China has been historically dependent on OPEC Oil and it is one of the most vulnerable economies that depend on the regular uninterrupted supply of Oil for the growth and functioning of its vast economy. Since fossil fuels are depleting at a rapid rate, it is stated to be one of

Fig. 22 Sample 1 of the report submitted by the learners



Energy Efficiency and Resource Consumption

By D[redacted]h

Efficient energy use, sometimes simply called **energy efficiency**, is the process of reducing the amount of energy required to provide products and services. Decreasing energy use reduces energy costs and may result in a financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy-efficient technology. Improved **energy efficiency in buildings, industrial processes and transportation** could reduce the world's energy needs in 2050 by one third, and help reduce global emissions of greenhouse gasses.

"*Increasing energy efficiency is the quickest and least costly way of addressing energy security, environmental and economic challenges."*

Solutions in mathematics have roots that satisfy the problem; any practical change induced along the roots of problems will bring up the desired changes. The scientific community has resorted to developing an outlook at a very basic level to deal with energy consciousness.
An energy audit or Energy Assessment has become a concerning chat in households. This is because of the rising concerns all over the world with respect to being "Energy Efficient". Legislations and Housing regulations are particularly debating on intensifying sustainable goals due to the considerable share of households contributing to carbon emissions. Building sectors have started relying on scientific discoveries to conduct energy testing with some initial setbacks. A quick glance at the processes of an energy audit from *Energy 101* :

Through the process, the home assessor will gather information and produce a report including characterizations of your home and actions you can take to reduce your home's energy use while increasing the comfort of the living space. Common recommendations often include:

1. Conduct whole-home air sealing to reduce air leakage and drafts.
2. Add insulation to your home's attic, foundation, or walls to prevent heat loss.
3. Seal and insulate ducts in unconditioned spaces.
4. Remove or repair any parts of the home with internal moisture or mould to improve air quality and reduce deterioration.

Fig. 23 Sample 2 of the report submitted by the learners

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Data availability All the data of this qualitative, exploratory study can be made available on request.

Declarations

Disclosure statement The authors declare that they have no competing interests.

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