

Exploring evolving ‘problem spaces’ of large language models: mediation relationships between users and the new technology in teaching and research in Chinese higher education

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Abstract

This article examines engagement with large language models (LLMs) in Chinese higher education, focusing on their use in teaching and research in early 2025. A case study based qualitative research approach, focusing on LLM users at a Chinese university recognised for its teacher education, was supported by a review of contemporary LLM related literatures. Researching the issue of the ‘danger/promise paradox’ of a rapidly evolving technology involved adapting Celia Lury’s concept of ‘problem spaces’ within a wider geo-political economy framework. The primary research suggests a relatively ‘unmediated’ relationship between users and the new technology, reflected in calls from interviewees for more guidelines and support both nationally and institutionally. Without ‘progressive mediation’, it is argued that the positive potential of LLMs could be reduced and dangers amplified. The final section suggests that increased strands of mediation activity could be key to a ‘recomposing’ of the LLM problem space.

Introduction

Rapid LLM development and the emerging paradox

Large language models (LLMs) represent a paradigm shift in the world of artificial intelligence as they evolve as increasingly powerful tools to enable machines to understand and generate human-like text with accuracy and conversational capabilities (Naveed et al., 2025). Within this rapid development has emerged the ‘LLM danger/opportunity paradox’; rooted in the tension between the creative features of the LLM and the dangers that arise precisely from that capability. The paradox deepens as LLMs become more sophisticated, making it increasingly challenging to distinguish between human-generated and AI-generated content (Yan et al., 2023; Peláez-Sánchez et al., 2024). It is this inherent duality that forms the core of the danger/opportunity paradox understood here as the ‘LLM problem space’.

Diversification of models

The LLM model availability landscape is also rapidly changing, with initial dominance of the ChatGPT series being challenged by newer entrants with Microsoft Copilot and Perplexity integrating AI into productivity tools and Anthropic's Claude 3.7 Sonnet and Google's Gemini Ultra developing multi-modal capabilities (Dilmegani and Palazoğlu, 2025; Cardillo, 2025). Additionally, parallel Chinese LLM developments (e.g. Baidu's Ernie Bot (Wenxin Yiyan), Alibaba's Tongyi Qianwen and Tencent's Ziya) have emerged to achieve top rankings in global benchmarks (Lin, 2025). And significantly, early 2025 saw the arrival of the Chinese LLM DeepSeek V3 as a game changing player due to its cost-efficiency, challenging the belief that high-performance AI requires extensive computational power (Dixit, 2025, Singer and Sheehan, 2025). Additionally, DeepSeek's commitment to open-source development is allowing its internal architecture and advanced methodologies to facilitate the development of more specialist LLMs globally that are trained on domain-specific data, offering deeper insights and more accurate interpretations of research within specific fields (Guizani et al., 2025; Medikepura Anil, 2025).

The LLM danger/opportunity paradox in compressed time

These advances have been reflected in the rapid growth of popular usage. As of early to mid-2025, LLM adoption in the United States shows significant penetration, with approximately 52 per cent of the adult population (aged 18 and above) reporting personal or work-related use of AI large language models (Elon University, 2025). Meanwhile, popular engagement with LLMs in China is also extensive; by June 2025, 81 per cent of China's internet users (a base exceeding 1.12 billion) were utilizing generative AI products for tasks such as answering questions (China Daily, 2025).

The rapid evolution of LLM capabilities and availability is also driving application across different sectors including customer services (e.g., advanced chatbot agents); legal services (e.g., assisting with contract analysis and legal research); health and social care (e.g., aiding in diagnostic support by analysing patient data); finance (e.g., automating fraud detection); marketing (e.g., creating targeted advertising copy); and education (e.g., developing adaptive learning materials) (Analytics Vidhya, 2025).

This application surge has deepened the LLM danger/opportunity paradox. While LLMs provide new time-saving opportunities in relation to routine and increasingly more complex informational tasks, the attendant dangers are already many and varied. These include the large-scale manufacture

of misinformation, deepfakes and impersonation content, the erosion of critical thinking and information literacy, potential copyright infringement and intellectual property theft, the amplification of biases and discrimination, and broader societal disruption through job displacement and issues of equity (Coeckelbergh, 2024; Kasneci et al., 2023; Yang et al., 2023).

Compounding the LLM paradox is the velocity of technological change gives the appearance of shrinking distances and the speeding up of time (Harvey, 1989). Harvey's seminal work 'The Condition of Postmodernity' at the end of the 1980s reflected on a decade of globalised economic and technological change that superseded the Keynesian era. By way of comparison, at the time of writing the LLM technological wave now penetrating the layers of globalised society is only three years old, a phenomenon referred to here as 'compressed time'. This temporal dimension is placing considerable pressures on the pace of social and institutional adaptation (WEF, 2023).

Divided opinion – optimism and concerns

These contrasting impacts have, unsurprisingly, divided opinion. In the field of education, the transformative potential of LLMs elicits varying degrees of optimism related to perceived efficiency gains and expanded access to information, together with the possibilities of enhancing teaching and learning aligned with the principles of the Education 4.0 paradigm (Upadhyay et al., 2024; Peláez-Sánchez et al., 2024). Conversely, these developments have been met with significant suspicion and concern, with some leading academics going as far as to suggest that the whole academic project could unravel (Harfe, 2025). Users and commentators alike have voiced apprehension over potential and real threats to academic integrity, including the facilitation of plagiarism (Kumar et al(a)., 2024; Shahzad et al., 2025) and worries about intellectual over-reliance on these tools in research that could undermine the development of critical thinking and problem-solving skills (Kasneci et al., 2023). Furthermore, the inherent biases embedded within LLM training data raise serious equity issues, risking the amplification of social and educational inequalities (Cuskley et al., 2024; Yang et al., 2023). The sheer velocity of LLM development means that these concerns are emerging and evolving almost as quickly as the technology itself, creating a dynamic landscape of perceived promise and peril.

Distribution of ethical responsibilities

Within the LLM paradox and compressed space-time, balances of danger/opportunity are inextricably linked to the distribution of ethical responsibilities. While the primary ethical burden initially rests

with producers due to their foundational decisions on architecture, training data, and safety mechanisms that directly influence a model's performance and potential for bias or harm (Dexoc, 2024), the advanced capabilities and widespread adoption of LLMs quickly distribute these responsibilities to various user groups—employers, professionals, and individual citizens - underscoring that ethical governance of LLMs requires a multi-stakeholder approach across the entire AI lifecycle (University of Oxford, 2023; Kumar et al(b)., 2024).

This distribution highlights three important considerations. The first involves a recognition that the dangers of LLMs are not only embedded in the technology, but also in the outlook and purposes of users. The educational dangers of plagiarism and intellectual over-reliance, for example, are primarily the responsibility of students and academics functioning within competitive education systems (Eaton, 2023). Second, it should be acknowledged that the balance of powers within the distributive relationship - between producers, employers and various users - remains highly unequal, leading to the question as to these can become more equitable (Pew Research Centre, 2021). Third, and in the light of the preceding two issues, is the challenge of mediation between users and the technology – an issue that became a central concern of the research.

Opening research questions

In the light of this introductory analysis, the research process and analysis were framed by an overarching question and three sub-questions.

In what ways is the LLM danger/opportunity paradox reflected in teacher perceptions in the case-study institution?

- a. What are the factors affecting the adoption of LLMs by educators in the context of China-specific and wider global trends?*
- b. How are LLMs being used in teaching and research in this Chinese university across various disciplines?*
- c. How far is the application of LLMs being affected by mediating factors such external and institutional guidelines and the provision of resources and training?*

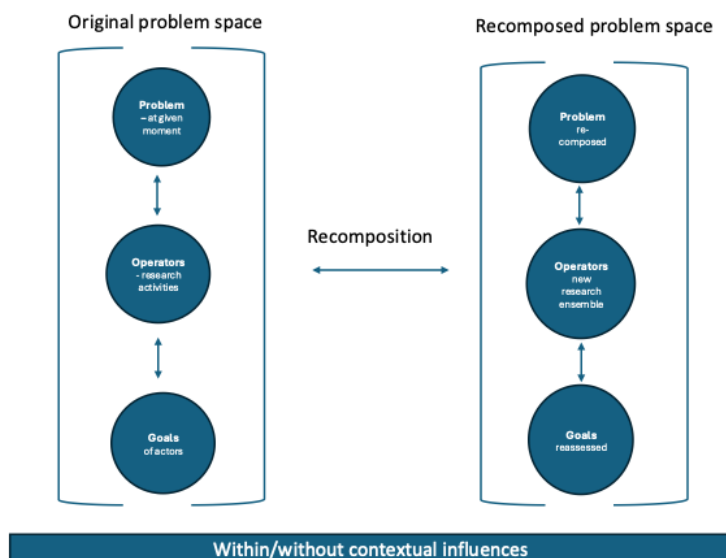
The final part of the article returns to these opening questions while also posing new 'recomposed' questions arising from the research.

Researching the LLM danger/opportunity paradox

LLM 'problem spaces'

The main research problem concerns the paradoxical relationship between the opportunities LLMs provide to enhance teaching, learning and research and the dangers of misuse and intellectual over reliance. In view of these complexities, it was decided to adapt Celia Lury's (2021) concepts of 'problem spaces' that conceptualises the evolving inter-relationship between three key elements - the 'problem' at any given moment; the 'goals' of actors involved in the problem space; and 'operators' - the actions, methods and practices applied to understand and transform the problem space. As a way of researching the evolving problem space, she also calls for a 'compositional methodology' in which researchers must compose new ways of interacting with the unfolding phenomenon. The key to Lury's twin concepts is the interplay between these elements as a feedback loop in which problem spaces are perpetually in a state of 're-composition', thus challenging traditional views of research as a static given problem and the idea of researcher 'independence'. Her original problem space research model is interpreted and illustrated in Figure 1.

Figure 1. Interpreting Lury's concept of evolving problem spaces



Adapting and extending the problem spaces model

It was decided that the complexities of the LMM paradox required four extensions to Lury's original model – the idea interacting socio-system levels, the role of actors operating within and between these levels, the concept of progressive mediation and a chrono-dimension of compressed time. All four factors function implicitly within the original problem space model, but extended model makes them more explicit and active.

Interacting system levels – going beyond the recognition of the embedded nature of problem spaces, technology driven problem spaces are conceived here as interacting levels in socio-technological systems due to the LLM problem space being spread across global, societal and institutional scalars. This multi-level analytical approach has been derived from a social ecosystem adaptation of Bronfenbrenner's human ecological systems (1979) applied to the world education (Spours, 2024). The interacting levels in the adapted model comprise - global technological models, macro regional and national regulatory frameworks, meso institutional factors, and micro relations of individuals and small groups (see Figure 2).

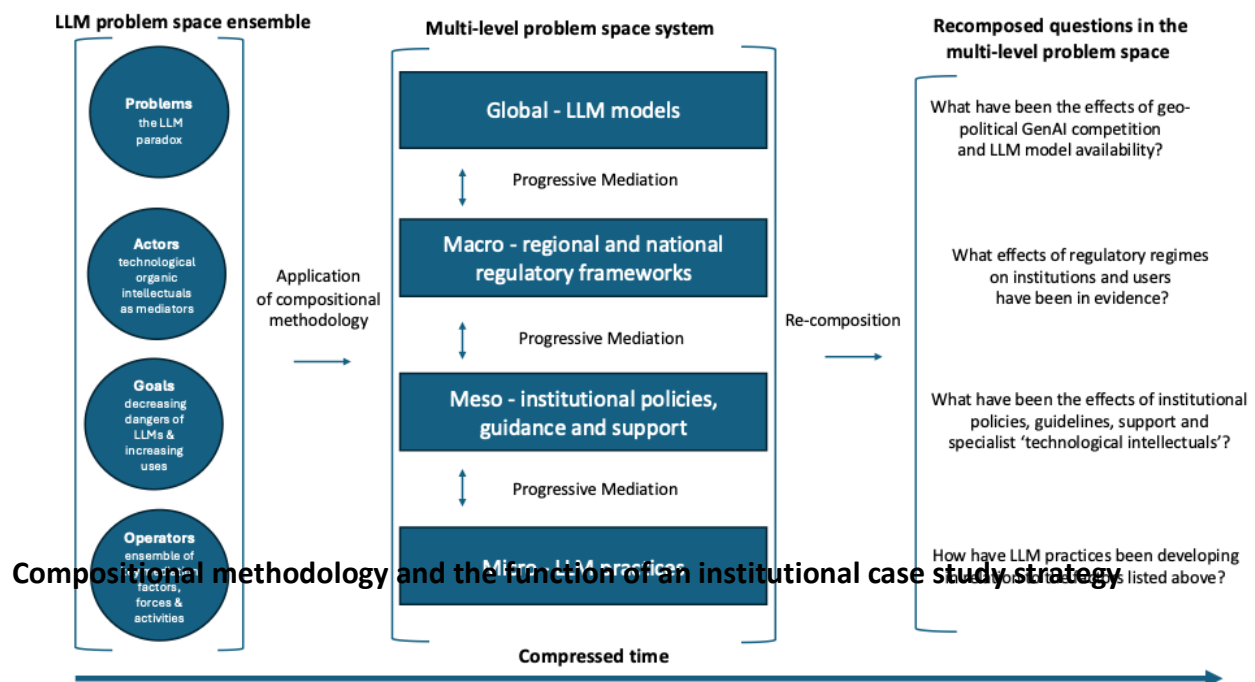
The connective role of social and technological actors – while the levels of a technological system can interact by virtue of the downward pressures of globalised technological models, the research required the conceptualisation of the role of connective actors at the different system levels. This conception develops concept of 'organic intellectuals' (Gramsci, 1971 translation) as 'technological organic intellectuals' – individuals and/or groups who possess both a technical understanding of generative AI and its capabilities together with a commitment to social, ethical, and political purposes, informed by contemporary analyses of digital capitalism (e.g., Dyer-Witthford, 2015; Fuchs, 2020; Gilbert and Williams, 2022).

The concept of progressive mediation – in the case of LLMs, mediation refers to activities and frameworks to bridge the relationship between LLM users and the technology across the socio-technological system levels. Mediation is deemed 'progressive' insofar as these activities attempt to mitigate the dangers of LLMs while maximizing fostering ethical development. In the context of this research, the role of progressive mediation was focused mainly on the connection between micro- and meso-levels - LLM users acting within the case study institution. Drawing on Cultural-Historical Activity Theory (CHAT) (Engeström, 1999), progressive mediation can also be understood as the collective process by which 'boundary crossers' actively work through contradictions within and between activity systems to transform the LLM problem space towards more desirable outcomes.

The effects of compressed time – the LLM problem space is complicated by the effects of the velocity of technological change that shows little sign of slowing. Compressed time had two immediate implications for the research. First, significant technological change took place during the primary research phase, referred to later as the ‘DeepSeek Moment’ that significantly altered the pattern of LLM usage in the institutional context. Second, the rapidity of change has left higher education institutions globally running to catch up (EDUCAUSE, 2025), the consequences of which became highlighted in the interviews related to the relative absence of institution-based mediation mechanisms.

The addition of these four factors constitutes an elaboration of Lury’s problem space model (see Figure 2). The LLM ‘problem space ensemble’ (Column 1) represents the totality of relations comprising - given problems, key actors, their goals, progressive mediation activity - all operating under the pressures of compressed time. The problem space ensemble is seen as contributing to the compositional methodology to be applied to multi-level problem spaces (Column 2). Contextual ‘without/within influences’ are now represented by multi-level problem spaces (Column 2) ranging from global to micro. The original research questions, emerging as ‘recomposed’ research questions, are listed in Column 3. These informed the analysis of the primary data and are revisited in the final section.

Figure 2. Extension of Lury’s concept of problem spaces



Researching the multilevel LLM problem space required a variety of data gathering and conceptual approaches, referred to by Lury as ‘compositional methodology’. The global and macro levels of the problem space system were researched using contemporary generative AI literatures, as were elements of the problem space ensemble. The issue of compressed time was acknowledged by the two batches of interviews being three months apart, followed by focus group discussion a month later. This chronology helped to track the unfolding usage of LLMs by the research participants. Furthermore, it is intended to revisit LLM usage during a proposed institutional development programme in late 2025.

The meso and micro levels of the problem space and the recompose questions, were investigated through a contextualised case study strategy. Additionally, the findings from the case study research were compared with those from recent surveys carried out in higher education institutions (Educause, 2025). The concept of problem spaces reinforced the decision to use a single, descriptive case study strategy (Nohria, 2021), to investigate complex context-specific dynamics (Yin, 2018). This approach is aligned with Lury's 'compositional methodology,' which emphasizes situated engagement with phenomena as they unfold and are continually recomposed within specific contexts.

The case study higher education institution - is in a first-tier Chinese city and ranked highly for its output of trained teachers for various education levels. In recent years it has achieved double class status in particular disciplines and operates as a Ministry of Education Demonstration Base for International Students and a Talent Training Base for ‘Belt and Road’ countries. The university has large colleges of education, technology and engineering that became the primary sites for qualitative data gathering, comprising two stages to best understand the evolution of the evolving problem space related to the adoption and application of LLMs in the case-study setting.

Selection of the user research sample - the LLM user participants were primarily recruited through recommendations based on diverse professional backgrounds (e.g. education, technology and engineering), teaching experience, and familiarity with LLMs (see Table 1 for details). In addition to the initial group of participants, the research team also utilised a snowballing approach in which these teachers were asked to recommend other potential participants who were actively exploring new technologies in their teaching or research.

Table 1. Profile of the interview sample

Characteristic	Education (N=8)	Engineering (N=12)	Overall Sample (N=20)
Gender	Male: 4	Male: 6	Male: 10
	Female: 4	Female: 6	Female: 10
Age	31-40 years: 4	31-40 years: 8	31-40 years: 12
	41 years and above: 4	41 years and above: 4	41 years and above: 8
Title	Professor: 1	Professor: 3	Professor: 4
	Associate Professor: 2	Associate Professor: 1	Associate Professor: 3
	Lecturer: 5	Lecturer: 8	Lecturer: 13

Semi-structured interviews – a total of 11 teachers were selected for interview in January 2025 and a further nine for interview in March. The interview process employed a progressive approach, starting with professional background information, followed by questions on LLM usage before moving to more complex issues concerning the use of LLMs in teaching and research.

Focus group discussion - five members of the focus group were selected from the 20 participants in the first round based on their high levels of engagement. The focus group discussion took place in April 2025 and was able to elaborate on themes arising from the first two interview rounds.

Ethics - throughout the research process, particularly in the approach to the research participants, the research team strictly adhered to established ethical principles and practices, including informed consent procedures, transparency processes, information on the right to withdraw, the anonymising of personal information and the storage of data on a secure server.

Key factors applied to the primary research and analysis

A series of key factors were identified from the review of literatures on LLMs to help frame the interview schedule and subsequent analysis. These included - the extent of LLM awareness and their potential usage (e.g. IDEAS, 2024); the application of LLMs to teaching and research (e.g. e.g. Ash and Hansen, 2023; Jeon and Lee 2023); institutional policies, resourcing and training (e.g. Wang et al., 2024); challenges to adoption (e.g. Yan et al., 2023); and prospects for LLM development and their applications to teaching and research (e.g. Fuchs, 2023).

The wider contexts of geo-political competition and settings of higher education

Building upon the multi-level conceptualization of the LLM problem space, this section shifts the focus to the Lury's 'within/without' contextual influences that shape the ongoing danger/opportunity paradox. Globally, the development and deployment of LLMs are increasingly entangled with geo-political competition driven by national strategic interests and the pursuit of technological sovereignty (García-Herrero & Krystyanczuk, 2025; WEF, 2025), exerting significant pressures on environments within which higher education institutions operate (Hausman et al., 2025).

Chinese-US technological competition and its effects

Geopolitical competition is considered a particularly influential factor in this study because it impacted the Chinese LLM landscape in the period leading up to and during the research. Until recently, China had faced distinct technological challenges with Chinese LLMs struggling with accuracy and robustness (Zhang et al., 2023a; Chen et al., 2023), reflected in the fact up until 2025 the ChatGPT series held sway, not only in the US but also in China. This started to change in 2024, with the emergence of several high performing generic LLMs (Lin, 2025), including Baidu's Ernie Bot (Wenxin Yiyan), Alibaba's Tongyi Qianwen, Tencent's Ziya and HighFlyer's DeepSeek (Thormundsson, 2025). In early 2025, the Chinese DeepSeek LLM arrived as a significant player in the global AI sector, a development of which had a significant effect on LLM usage in the case study institution.

On the surface, the relationship between US and Chinese LLMs could be interpreted simply as globalised market competition, but underneath different types of politics and governance were at work. While both LLM 'systems' share common technical features, China and the US have been developing distinct LLM approaches with differing underlying political economy logics (Jiang, 2024). The US model is largely market-driven whereas the Chinese model is mainly state-driven, reflecting the distinction between different types of capitalism – liberal market and coordinated (Hall & Soskice, 2001). China's strategic 'whole nation' commitment to LLM development is evidenced by substantial national investments and supportive policies in AI research and infrastructure (Yin, 2024). In the US, on the other hand, LLM development has been driven more by private sector innovation and academic research, supported by substantial venture capital and public funding. Together, these function as the leading edge of what has been termed a neoliberal version of 'platform capitalism' (Gilbert and Williams, 2022). But neither the Chinese nor US LLM systems are 'pure types': each contain elements of the other albeit in differing proportions.

Moreover, there are elements of convergence, although with subtle differences. Rapid developments in both China and the US have fuelled concerns about ethical implications of LLM usage, capable of generating a climate of suspicion that could inhibit LLM uptake (Yang et al., 2023). Consequently, in regulatory field the US model has focused on ethical concerns, data privacy, and the potential misuse of AI technologies (Ash and Hansen, 2023). The regulatory environment in China, on the other hand, has been generally more supportive of rapid AI development, although there are established legal frameworks including standards for AI ethics, data security, and transparency (Tindall, 2024). It is interesting to note, therefore, that in the field of generative AI China appears to be adopting an innovation-led rather than strictly regulatory strategy, aided by the emergence of advanced Chinese LLMs that function well within the overall Chinese technological and informational ecosystem (Zhang, 2025). The primary research unearthed interesting reflections on this apparent paradox, reported later in the article.

LLMs in higher education settings

A growing literature on the integration of LLMs in higher education, that now include surveys and meta literature reviews (e.g. Wang et al., 2024, UNESCO IESALC, 2025), point to significant opportunities and challenges. LLMs can enhance learning experiences by providing personalized and adaptive learning, tailoring educational content to meet individual student needs, and offering customized feedback and support (Jeon and Lee, 2023, Chen et al., 2024a, Chen et al., 2024b). They also can serve as teaching assistants, helping educators with tasks such as grading, content creation, and providing additional resources, thus freeing up teachers' time for more interactive and student-centred teaching practices (Peláez-Sánchez et al., 2024). Generic LLMs can be particularly useful in education research for tasks such as resource access, conducting literature reviews, summarizing research papers, and generating educational content (Guizani et al., 2025). Moreover, LLMs can under certain conditions foster creativity and critical thinking by engaging students in dynamic learning activities and simulating real-world scenarios (Peláez-Sánchez et al., 2024).

Nevertheless, as in wider society, the growing use of LLMs in higher education by both staff and students, has raised ethical and privacy concerns, potential misuse and possible for bias in AI-generated content, which could also perpetuate existing educational inequalities (Williams, 2023). In a setting that values the development of high-level conceptualisation, there is a major risk of overreliance on LLMs that could undermine the development of critical thinking and problem-solving skills (Kasneci et al., 2023). Additionally, the relationship between teachers and AI is crucial, as effective integration requires a

collaborative approach where AI tools complement rather than replace human teachers (Jeon and Lee, 2023), raising issues of the extent of collaborative cultures in their implementation settings.

The use of LLMs in research and academic writing raises significant issues concerning relational authorship and cognitive distribution, where the boundaries between human and machine contributions are becoming blurred (Helliwell, 2019; Clarke, 2025). This raises questions about the attribution of credit and the ethical implications of co-authorship with non-human entities (Bedorf, 2024; Cuskley et al., 2024) and necessitating new frameworks for evaluating the originality and integrity of research outputs (Jeon and Lee, 2023). Steps have already been taken to increase transparency and trust, for example, van der Schaar's model of 'interpretability, explainability and trustability' (Imrie, Davis, & van der Schaar, 2021) being used in clinical practice, with the possibility of being adapted to other fields (Ennab and Mcheick, 2024)

LLMs in the Chinese higher education context

China's educational policies have emphasized modernization and innovation with the 'China Education Modernization 2035' plan focusing on fostering national strategic sci-tech capabilities and promoting digital education frameworks driven by AI (State Council, 2025). Within this macro policy landscape, the unique cultural dynamics of Chinese higher education appears to shape the adoption and perception of LLMs. With a strong emphasis on academic achievement, often driven by high-stakes examinations and a culture that values knowledge acquisition, LLMs are increasingly viewed as tools to enhance efficiency and access to information within these established norms (Li & Wang, 2023; Asia News Network, 2025).

At the same time, there are Chinese concerns about the role of LLMs in academia but framed somewhat differently than in the West. Chinese universities are aware of issues of academic integrity, data privacy, and bias and are implementing regulations regarding AI use in academic writing, such as the use of generative AI in academic writing, particularly for graduation theses (The Straits Times, 2025). However, the discourse can be seen to align with a state-led approaches to managing and controlling these risks to ensure AI serves national educational and strategic objectives with a focus on responsible integration and ethical alignment with national values and educational goals (China Law Vision, 2025), suggesting a relatively pragmatic approach to the technology's integration rather than a widespread dread of the pending demise of the 'academic project' (Müller et al., 2025).

The use of LLMs in the case-study institution

The research employed a single-case, institution-based study with a slightly longitudinal approach, designed for a deep dive into staff perceptions of LLMs at three points in early 2025. The core strength of a case-study strategy lies in its ability to provide holistic and in-depth understanding of perceptions within their real-life contexts, (Stake, 1995). Conversely, the primary limitation is the challenge of generalizability, as findings from a single institution may not be directly transferable to other higher education contexts due to unique contextual factors (Flyvbjerg, 2006); a limitation necessitating not only case contextualisation but also data triangulation (Patton, 2015). The final part of this section compares the case study data with wider higher education data on LLM use to help reinforce the validity of the primary research.

Findings from the interviews

The reporting categories of the primary research have been framed by the key factors derived from secondary sources concerned with LLM awareness and usage, the application of LLMs in teaching and research, perceptions of the main challenges, the extent of institutional support, and views about prospects of LLMs in university life (e.g. Kasneci, et al., 2023; Sallam, 2023; Bobula, 2024, Liao, 2024). Taken together, these key factors constitute the parameters of the ‘LLM problem space’ in the local setting. This section reports staff perspectives distilled from the two batches of interviews undertaken in January and March 2025.

LLM awareness and model usage

Usage and awareness of different LLMs was widespread among the sample of staff members across the three departments involved in the research. However, levels of engagement appeared to vary.

‘As a tech enthusiast, I believe these models have the potential to significantly improve educational methods and outcomes’. (T-M-W)

At the same time, these users were aware that not all teachers were using LLMs, a situation related to mindsets.

‘Some teachers might have very fixed mindsets... If their mindset is too rigid, they might find it difficult to accept new things’. (M-M-Y)

That said, the use of LLMs in the sample was extensive with many participants using several models, due to each LLM having particular strengths. The top five are listed in Table 2.

Table 2. LLM usage in case-study HEI (January & March 2025)

Ranking of LLMs by Chinese HE users - 2025	Ranking of LLMs by university users - January 2025	Ranking of LLMs by university users - March 2025
DeepSeek ChatGPT Doubao Wenxin Yiyan Kimi	ChatGPT - 17 mentions Doubao - 9 mentions Kimi - 9 mentions Wenxin Yiyan - 7 mentions iFlytek Spark - 3 mentions	DeepSeek - 31 mentions ChatGPT - 15 mentions Doubao - 2 mentions Wenxin Yiyan - 2 mentions Kimi - 1 mention

Source for Column 1. *LLM Leaderboard: Analyze and compare AI models across benchmarks, pricing, and capabilities.*

Several points stand out from this brief comparative exercise. First, the case-study HEI users appear to be broadly in line with national usage in terms of LLM ranking listed in Column 1. Second, Columns 2 and 3 reveal what could be referred to as the ‘DeepSeek Moment’ when this Chinese LLM broke onto the AI scene in February 2025. Unsurprisingly, there was no mention of it in January, but it subsequently led the leader board in March. Third, specialist LLMs did not make it into the top five rankings.

Most interviewees expressed a basic understanding of LLMs as AI tools capable of text generation, translation, and content, with awareness often stemming from personal experimentation rather than formal training, as noted by a mathematics professor.

‘I learned about LLMs through online resources and started using ChatGPT before it became widely popular’. (T-F-Y)

On the other hand, awareness and engagement levels appeared to vary by discipline. For example, participants from technology and engineering colleges tended to engage more deeply with LLMs, exploring their technical capabilities and limitations with a computer science professor noting.

‘We use LLMs to test algorithmic ideas and debug code, which requires understanding their strengths and weaknesses’. (T-F-X)

In comparison, humanities and social sciences interviewees in the Education College tended to approach LLMs with a more practical lens, focusing on their utility rather than technical specifics.

'I don't need to know how they work—just how to use them effectively'. (E-M-H)

They also tended to view them with caution, emphasizing ethical concerns and academic integrity.

'While LLMs can generate text, their outputs lack the nuance required for truly original scholarship'.

(T-M-L)

Application of LLMs in teaching and research

Interviewees reported extensively utilising LLMs in relation to their teaching and research.

Teaching – LLMs are being used in a variety of ways in teaching, in relation to lesson planning, organising course content, creating teaching materials and engaging with student learning. In terms of organising learning, they are assisting teachers to create detailed lesson plans, streamline the preparation process and ensure comprehensive coverage of topics, with one interviewee commenting:

'I mainly use it to organize and refine the course content. It can sort out relevant classic experimental cases and cutting-edge research progress based on the course topics I provide'. (T-M-Z)

In their assistive teaching role, LLMs are providing personalized learning support by offering customized learning content and guidance based on students' questions and learning situations, helping students grasp course knowledge more effectively and encouraging independent learning, particularly in relation to complex questions, with one teacher noting:

'In the classroom, I have students ask ChatGPT questions about certain knowledge points and then discuss whether the answers it provides are reasonable, thereby cultivating students' critical thinking'. (T-M-R)

When interviewees were asked about their views on the future implications of LLMs for teaching and learning, their responses echoed evidence from the wider literatures, referring to more diversified teaching approaches, combination with virtual reality technologies for immersive learning experiences, becoming virtual teachers/assistants for 24-hour support and support for the 'flipped classrooms' in which LLMs are used by students for pre-class preparation. At the same time, they were clear about the conditions required for these advancements, referring particularly to the need for improvements in digital literacy of both teachers and students and resourcing to address equity issues.

Research - at the same time, LLMs are being increasingly integrated into research across various disciplines by offering significant advantages in source identification, idea generation, and content creation.

'In research, I use it for preliminary literature reviews to quickly extract key information from relevant literature, saving time that would otherwise be spent on reviewing a large number of papers'. (T-M-R)

'AI can also provide some inspiration in terms of viewpoints. Because its output is based on a large corpus and database, the information it provides can sometimes stimulate people's inspiration'. (T-M-Z)

Further along the research and writing process, LLMs are being used in text polishing and translation to assist in refining the language of research papers, ensuring grammatical accuracy and improving readability.

'For writing papers, I might ask it to help refine or organize the concept... Content is always my own'. (T-M-Y)

'In terms of scientific research, I tend to use it as a tool for looking up academic concepts and for finding alternative academic terms when I feel that I am overusing certain words to enhance the diversity of language'. (T-M-Z)

Generic LLMs are also being used in more specialist ways, although this was a minority practice. In fields like computer science and engineering, for example, they are being used to generate and debug code, significantly speeding up the development process.

‘For coding or plotting, it’s quite accurate. I prepare the data and specify requirements—like building a framework—then let it generate the code’. (T-M-Y)

Overall, with their ability to automate repetitive tasks that include the streamlining of literature reviews and material preparation, LLMs may be helping university teachers to make time savings with the potential to release more time for improved generation of creative ideas, enhancing personalization of learning experiences for students and providing better accessibility to information and cross-disciplinary knowledge. At the same time, the opportunities offered by LLMs have their dangers, of which the participants were acutely aware.

Challenges for users

Interviewees recognised a range of challenges. Technical issues included ‘hallucinations’ (inaccurate information generation).

‘The reliability of the content is a concern. For formal academic work, I can’t fully trust the generated content without verifying it’. (T-M-W)

‘Fabrication is the main issue, and it brings about problems of scientific accuracy. If teachers can identify the fabricated content, that’s fine—we can stop the problem in time. But if students can’t tell the difference, and they go on to give presentations or reports in various settings, the very foundation of education will be lost’. (T-F-Q)

And even when LLMs were working as expected, contributions were seen as limited.

‘The model might generate a lot of content, but only a small portion is actually useful’. (T-F-W)

Teachers were, nevertheless, aware that better prompting helped with accuracy.

'The more straightforward and detailed I make my questions, the better the answers I get'. (M-M-Y)

Despite rapid technical advances, with the 2025 models hallucinating far less than earlier ones, ethical issues remained a problem. In fact, this challenge may be growing as the technical capacity of LLMs increase. Concerns were mainly related to problems of academic integrity and over-reliance on technologies.

'I think the ethical aspects are relatively obvious. For example, if an undergraduate wants to complete his graduation thesis, the easiest way may be to ask AI. This may lead to academic misconduct'. (T-F-W)

'When I guide students, I can immediately tell if a paper was written by a student using a large language model—it's obvious. It could be either plagiarized or generated by ChatGPT. I'm not really recommending or encouraging its use because it's hard to control'. (E-M-L)

Related to this is the fear of over-reliance by university teachers.

'For most teachers, especially in the humanities and social sciences, using too many large language models could be problematic'. (E-M-L)

'I think AI is essentially a tool. It should not replace people in doing things. On the contrary, it should be used for auxiliary work after people have certain ideas'. (T-M-Z)

The evidence thus far suggests that, while this sample of university teachers are using LLMs creatively, they are also aware of technological and ethical limitations.

Institutional guidelines, resourcing and training

An important point to recognise at this stage, is that interviewees had arrived at their positions independently and without significant institutional support, with most teachers relying on personal initiative and informal sharing of resources, with the relative absence of formal policies or guidelines from institutions.

'No, I haven't heard of any policies at our school'. (T-M-Z)

Resourcing was also seen as an issue.

'The main difficulties are the daily usage limits. Once the limit is exceeded, the model's performance is downgraded unless I pay a fee'. (T-M-L)

Conversely, the emergence of Chinese open-source models was seen as providing a way forward.

'I think there is a lot of support now that there is open source and free to use'. (T-F-G)

In addition to issues of guidelines and resources, the relative lack of training and institutional support emerged as a significant issue.

'I started using them on my own and learned as I went along'. (T-M-W)

'I mostly rely on self-study, including watching videos and attending expert lectures'. (T-F-H)

And when institutional support was available, it was sometimes in short supply.

*'Our college did offer a session on using AI for teaching and research, but it was oversubscribed'.
(T-F-W)*

Not surprisingly, there were calls for increased institutional support and guidance with the following quotes summarising prevailing sentiment.

'I think it is necessary to establish a standard for using AI, especially for college students. There should be a set of established standards so that they can use AI without crossing the line'. (T-F-W)

'If the institution could provide technical training to help teachers better master the use of large language models, improve questioning skills and result assessment abilities, it would help me use large language models better'. (T-M-R)

Prospects for LLMs

In view of the rapid evolution of LLMs, interviewees were asked to think about future developments. Most expressed optimism about the future integration of LLMs in higher education, while acknowledging the need for careful implementation. The following quotes capture expectations.

'I definitely have a very optimistic attitude... It will be more in line with our needs, and its processing efficiency will be higher, faster, and more accurate'. (T-F-G)

'I'm optimistic. Technological advancements will continue to drive change in education'. (T-M-W)

At the same time, the need for LLM customisation to enable more specialist application was also recognised.

'I hope they can offer more customized features to meet the specific needs of different disciplines and fields'. (T-F-F)

'I hope they can be tailored by the field... This would make them more focused'. (H-F-H)

Findings from the focus group discussion

The focus group discussion conducted in April 2025, involved five participants drawn from the Colleges of Education and Engineering, with the session focusing on the usage, benefits, and challenges associated with the use of LLMs and the role of institutional guidelines and support.

The group discussion confirmed that the research participants frequently use LLMs for various tasks in relation to teaching, researching and administration, appreciating their language processing capabilities, context memory, and efficiency in generating content. However, despite the benefits, several challenges were highlighted including data authenticity, system overload that appeared to affect DeepSeek in

particular, the penalties of ambiguous instructions, the potential for over-reliance on LLMs and the struggle of some models with integrating content into deeper knowledge hierarchies.

As a response, participants emphasized the need for better training and support from their colleges and the university to maximize the potential of LLMs, recommending policies and guidelines focusing on data security, ethical standards, and responsible usage. They went on to suggest integrating LLM training into the curriculum to address both benefits and potential drawback, with the development of practical institutional guidance on using LLMs effectively, training on ethical use and citation practices, financial support for subscription memberships, and advanced courses on the generation logic of LLMs.

Comparisons with wider data on LLM usage in higher education

The research findings from the case-study institution, encompassing both interviews and focus group discussions, resonate with trends observed in the broader research literatures (e.g. Kasneci et al., 2023; Upadhyay et al., 2024; EDUCAUSE, 2025). These include an appreciation for LLM capabilities in content generation with concerns about content reliability and scientific accuracy (Naveed et al., 2025; Yan et al., 2023). The awareness of academic integrity threats and the potential for intellectual over-reliance among the case-study participants also aligns with growing apprehension among educators worldwide, highlighting a universal concern for the foundational principles of scholarship (Kumar et al., 2024; Shahad et al., 2025). At the same time, there were interesting differences, an issue reviewed in the Discussion section.

Reflecting on both the primary data and the brief comparative discussion, it is necessary to make a distinction between the threats to academic integrity posed by students and by university staff. While both parties should be bound by ethical rules, the main ‘panic’ across universities globally presently appears to be focused on students, assessment and plagiarism (Hausman et al, 2025), potentially overshadowing the equally if not more important systemic issue of the use of LLMs in research and knowledge production (.

Discussion - provisional answers to the original and recomposed questions

The main point about compositional methodology is that it evolves through throughout the research process. And so, it was with the research questions involved in the study. As Table 3 illustrates, the recomposed research questions are more specific and active as the problem space evolves.

Table 3. The evolution of research questions

Original research questions	Recomposed research questions
1. In what ways is the LLM danger/opportunity paradox reflected in teacher perceptions in the case-study institution?	1. How far can the LLM danger/opportunity paradox be resolved by mediation frameworks and activities?
2. What are the factors affecting the adoption of LLMs by educators in the context of China-specific and wider global trends?	2. What have been the effects of geo-political generative AI competition and LLM model availability on LLM usage?
3. How are LLMs being used in teaching and research in this Chinese university across various disciplines?	3. What has been the balance of intentions and concerns in relation to using LLMs in teaching and research?
4. How far is the usage of LLMs being affected by mediating factors such external and institutional guidelines and the provision of resources and training	4. What kind of mediating activities and frameworks – external and internal - were being called for by the research participants?

Usage and mediation issue

Of all the potential factors affecting LLM adoption and application, the one that stood out in early 2025 was the emergence of the Chinese LLM DeepSeek V3. As Table 2 shows, as an advanced and open-source Chinese model, DeepSeek changed the local LLM adoption/usage landscape, diminishing reliance on ChatGPT for this user group. The DeepSeek ‘moment’ was reflected across Chinese society, particularly within the 18-34 age group, marked by increased uptake and debate about LLMs (Antony, 2025)

The relative absence of mediation, both institutional and wider frameworks, between academic staff users and the technology constituted a significant finding. There may be several reasons for this situation. Institutional factor may be at work, although contemporary accounts suggest that staff support gap could be more widely experienced (Mah et al., 2025; Legatt, 2025). Or, as suggested earlier, more attention is being paid to student relationships with AI than with staff. Or it could be the result of a research snapshot in time in which the technology has been accelerating and with regulation, national and institutional levels, running to catch up.

System factors may also be playing a part, due to Chinese approaches to regulation that is predominantly centralized at ministerial level and interwoven with national strategic imperatives aiming to harness LLMs for broader societal and economic transformation (State Council, 2025; Ministry of

Education, 2025), with the potential benefits of LLMs for national development and global competitiveness apparently given priority. Academic concerns would thus appear to be addressed pragmatically to maintain the integrity and functionality of the educational system as part of this larger strategy; therefore, going some way to explaining the relatively ‘unmediated’ experience at the institutional and individual user level. However, this may be a position that changes over time as the technology matures and Chinese higher education institutions develop their regulatory positions. As with the institutional level, only further research can cast light on these tendencies.

Conversely, Western and Global South higher education institutions have tended towards a more decentralized, institution-led approach to LLM mediation (Oytade and Zuba, 2025). While national bodies may offer guidance, the specific policies and implementation strategies are largely determined by individual universities, reflecting diverse academic cultures and governance structures. Here concerns about LLMs often delve into more philosophical territory, grappling with the potential impact on critical thinking, intellectual autonomy, and the essence of scholarship (Liang et al., 2025). This, however, does not necessarily mean that practical terms the LLM mediation landscape between China and the West is radically different, because the velocity of technological change is leaving all higher education institutions in a race to catch up. The comparison, however, does suggest differing political economy factors at work beneath the surface, with longer-term consequences.

Resolving the LLM problem space – building ‘strong mediation’

This group of university academics, as established users, were relatively optimistic about the role and future of LLMs in education. Nevertheless, they were also of the view that greater external and institutional support was needed to help realise the potential of LLMs while diminishing downsides.

Given that the operation of LLMs is spread across different scalars from the macro to the micro suggests that mediation activities should aspire to cover the same range (as illustrated in Figure 2). Here is suggested that mediation activities related to the research (e.g. guidance frameworks and support) must, in the first instance, be built at the institutional level. But the idea of ‘strong mediation’ – the combining of progressive interventions at different levels of the LLM system – suggests a longer-term building of a ‘mediation alliance’ that connects activities at institutional, city regional, national and global levels, with a key role for connective technological intellectuals (Spours, 2024). In addition, in relation to the meso and micro levels, the primary data suggests not only a role for institutional guidance, support and training from above, but also what has been termed ‘communities of practice’ (Rogers, 2000) from below.

Examining the responses of the research participants suggests that those interviewed possess sufficient expertise to make a significant contribution to the development of institutional guidelines, to shape training programmes both for themselves and their colleagues and to consider the wider intellectual and educational implications of this promising but problematical technology. In other words, through collective efforts, users could become a mediating force.

As for the future direction of development of LLMs, towards the end of the interviews, research participants were asked about prospects for LLM development. The prevailing sentiment was one of anticipation of the emergence of more accurate, specialized, and multi-modal models, reflecting views of specialist technologists that LLMs may progress into a phase of maturation as they develop multi-modal capabilities and enhanced reliability, rather than experience another quantum leap (Tredence, 2025). This optimism was, however, tempered by continued caution.

Final reflections return to the first recompose question - *How far can the LLM danger/opportunity paradox be resolved by mediation frameworks and activities?* In view of the research thus far, it would be more accurate and realistic to rephrase the question as to *how the opportunities provided by LLMs can be maximized and the dangers diminished*. Answers to this can only come from ongoing research on the evolving LLM problem space, as higher education institutions continue to grapple with increasing technological capabilities in a fluid geopolitical landscape.

References

- Analytics Vidhya. (2025). 'Top 10 Multimodal LLMs to Explore in 2025'. *Analytics Vidhya*, 3 March. Available at: <https://www.analyticsvidhya.com/blog/2025/03/top-multimodal-llms/> (Accessed: 30 July 2025).
- Antony, C. (2025). DeepSeek Statistics & Trends [2025] For Educators & Learners Today. *TeachNG*. Available at: <https://teachng.com/publications/deepseek-statistics> [Accessed 1 August 2025].
- Ash, E. and Hansen, S. (2023). 'Large language models for economic research: Four key questions'. *CEPR VoxEU*. - <https://cepr.org/voxeu/columns/large-language-models-economic-research-four-key-questions> (accessed 15 May 2025).
- Asia News Network. (2025). 'Artificial intelligence changing China's learning landscape'. *Asia News Network*, 19 February. Available at: <https://asianews.network/artificial-intelligence-changing-chinas-learning-landscape/> (Accessed: 30 July 2025).
- Bedorf, A. (2024). 'Building AI that clinicians and patients can trust – how to deal with 'Generalization''. *van der Schaar Lab* - <https://www.vanderschaar-lab.com/building-ai-that-clinicians-and-patients-can-trust-how-to-deal-with-generalization/> (accessed 24 November 2024).
- Bobula, M. (2024). "Generative artificial intelligence (AI) in higher education: a comprehensive review of challenges, opportunities, and implications", *Journal of Learning Development in Higher Education* [Preprint], (30). Available at: <https://doi.org/10.47408/jldhe.vi30.1137>.
- Bronfenbrenner, U. (1979). *The Ecology of Human Development: Experiments by Nature and Design*. Cambridge, MA: Harvard University Press.
- Cardillo, A. (2025). 'Best 39 Large Language Models (LLMs) in 2025', *Exploding Topics* - <https://explodingtopics.com/blog/list-of-llms> (accessed: 18 March 2025).
- Chen, L., Zhao, M., and Li, Y. (2024a). 'Adoption and Effectiveness of Large Language Models in Higher Education.' *Educational Research Review*, 48, 101-115.
- Chen, H., Li, X. and Wang, Y. (2024b). 'AI-Powered Personalized Learning in Higher Education: A Review of Current Applications and Future Directions'. *Journal of Educational Technology Development and Exchange*, 17(3), 45-60.
- Chen, Y., Li, X., and Wang, Z. (2023). 'Quality control in legal domain LLMs'. *Journal of AI Research*, 45(2), 123-135.
- China Daily (2025). 'China's records growth in internet users and AI technology'. *China Daily*, 21 July. - <https://www.chinadaily.com.cn/a/202507/21/WS687da1c6a310ad07b5d90f93.html> (Accessed: 31 July 2025).

- China Law Vision. (2025). 'AI Ethics: Overview (China)'. *China Law Vision*, 20 January. Available at: <https://www.chinalawvision.com/2025/01/digital-economy-ai/ai-ethics-overview-china/> (Accessed: 30 July 2025).
- Clark, A. (2025). Extending Minds with Generative AI. *Nat Commun* 16, 4627 <https://doi.org/10.1038/s41467-025-59906-9>.
- Coeckelbergh, M. (2024). *Why AI Undermines Democracy and What To Do About It*, Cambridge: Polity Press.
- Cuskley, C., Woods, R., and Flaherty, M. (2024). 'The Limitations of Large Language Models for Understanding Human Language and Cognition'. *Open Mind*. 8 1058–1083.
- Dexoc. (2024). 'Ethical & Legal Challenges in LLM Development: Issues & Solutions'. *Dexoc Blog*, 27 October. Available at: <https://dexoc.com/blog/ethical-legal-challenges-llm-development> (Accessed: 31 July 2025).
- Dilmegali, C. and Palazoğlu, M. (2025). 'The Future of Large Language Models in 2025'. *AI Multiple Research* - <https://research.aimultiple.com/future-of-large-language-models/> (accessed 18 March 2025).
- Dixit, A. (2025). 'Top AI Models of 2025: A Comparative Analysis of DeepSeek and OpenAI', *Flexxited*, 1 February - <https://flexxited.com/blog/top-ai-models-of-2025-a-comparative-analysis-of-deepseek-and-openai> (accessed 18 March 2025).
- Dyer-Witheford, N. (2015). *Digital Disconnect: From the Internet to the Post-Capitalist Alternative*. London: Pluto Press.
- Eaton, S. (2023). 'Generative AI and Academic Integrity: Definitions, Issues, and Responsibilities'. *Journal of Educational Research and Practice*, 23(1), pp. 1-10.
- EDUCAUSE (2025). *The AI Wake-Up Call for Universities: Key Insights from the 2025 EDUCAUSE Survey*. Available at: <https://www.umass.edu/ideas/digest/ai-wake-call-universities-key-insights-2025-educause-survey> (Accessed: 1 August 2025).
- Elon University (2025). 'Survey: 52% of U.S. adults now use AI large language models like ChatGPT'. *Today at Elon*, 12 March. Available at: <https://www.elon.edu/u/news/2025/03/12/survey-52-of-u-s-adults-now-use-ai-large-language-models-like-chatgpt/> (Accessed: 31 July 2025).
- Engeström, Y. (1999). 'Activity theory and individual and social transformation', in Engeström, Y., Miettinen, R. and Punamäki, R. (eds) *Perspectives on activity theory*. Cambridge: Cambridge University Press, pp. 19-38.
- Ennab, M. and Mcheick, H. (2024). 'Enhancing interpretability and accuracy of AI models in healthcare: a comprehensive review on challenges and future directions', *Frontiers in Robotics and AI*, 11,

- Article 1444763. <https://www.frontiersin.org/articles/10.3389/frobt.2024.1444763/full> [Accessed 1 Aug. 2025].
- Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12(2), 219-245.
- Fuchs, C. (2020). *Marxism in the Age of Digital Capitalism*. Leiden: Brill.
- Fuchs, K. (2023). Exploring the opportunities and challenges of NLP models in higher education: is ChatGPT a blessing or a curse? *Frontiers in Education*, 8. Available at: <https://www.frontiersin.org/articles/10.3389/feduc.2023.1166682>
- García-Herrero, A. and Krystyanczuk, M. (2025). 'The Geopolitics of Artificial Intelligence after DeepSeek', *Bruegel Working Papers*, node_10927. Available at: <https://bruegel.org/working-paper/which-companies-are-ahead-frontier-innovation-critical-technologies-comparing-china-european-union-and-united-states>. (Accessed: 1 August 2025).
- Gilbert, J. and Williams, A. (2022). *Hegemony Now: How Big Tech and Wall Street Won the World (and How We Win It Back)*, London: Verso Books.
- Gramsci, A. (1971). *Selections from the Prison Notebooks*. Edited and translated by Q. Hoare & G. Nowell Smith. New York: International Publishers.
- Guizani, S., Mazhar, T., Shahzad, T., Ahmad, W., Bibi, A., and Hamam, H. (2025). 'A systematic literature review to implement large language model in higher education: issues and solutions'. *Discover Education*, 4 - <https://link.springer.com/article/10.1007/s44217-025-00424-7> (accessed 18 March 2025).
- Hall, P.A., and Soskice, D. (2001). *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford University Press.
- Harfe, B. (2025). 'To Short-Circuit the Higher Education AI Apocalypse, We Must Embrace Generative AI', *The Hill*, 26 January.
- Hausman, N., Rigbi, O. and Weisburd, S. (2025). Generative AI in universities: Grades up, signals down, skills in flux. *VoxEU*. Available at: <https://voxeu.org> [Accessed 1 Aug. 2025].
- Harvey, D. (1989). *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change*. Oxford: Blackwell.
- Helliwell, A.C. (2019). 'Can AI Mind Be Extended?'. *Evental Aesthetics*, 8, pp. 93-120. Available at: https://eventalaesthetics.net/wp-content/uploads/2021/03/EAV8_2019_Helliwell_AI_mind_93_120.pdf (Accessed: 1 August 2025).
- Imrie, F., Davis, R. and van der Schaar, M. (2021). 'Multiple stakeholders drive diverse interpretability requirements for machine learning in healthcare', *Nature Machine Intelligence*, 3, pp. 737–745. Available at: <https://par.nsf.gov/servlets/purl/10481511> [Accessed 1 Aug. 2025].

- Instructional Design, Engagement, and Support (IDEAS) (2024). *The AI Wake-Up Call for Universities: Key Insights from the 2025 EDUCAUSE Survey* - <https://www.umass.edu/ideas/digest/ai-wake-call-universities-key-insights-2025-educause-survey> (accessed 22 May 2025).
- Jeon, J. and Lee, S. (2023). 'Large language models in education: A focus on the complementary relationship between human teachers and ChatGPT'. *Education and Information Technologies*. 0000. 10.1007/s10639-023-11834-1.
- Jiang, J. (2024). *China-U.S. Competition in Large Language Models: Global Perspectives on Opportunities and Challenges*. HKU Business School - <https://www.hkubs.hku.hk/research/thought-leadership/ft-chinese-column/china-u-s-competition-in-large-language-models-global-perspectives-on-opportunities-and-challenges/> (accessed 22 May 2025).
- Kasneci, E., Sessler, K., and Kasneci, G. (2023). 'Large Language Models for Education: A Survey and Outlook'. *arXiv:2403.18105* - <https://arxiv.org/abs/2403.18105> (accessed 15 May 2025).
- Kumar, R., Eaton, S.E., Mindzak, M., Morrison, R. (2024). 'Academic Integrity and Artificial Intelligence: An Overview'. In: Eaton, S.E. (eds) *Second Handbook of Academic Integrity*. Springer International Handbooks of Education. Springer, Cham. https://doi.org/10.1007/978-3-031-54144-5_153
- Kumar, A., Murthy, S.V., Singh, S. and Ragupathy, S. (2024). *The Ethics of Interactions: Mitigating Security Threats in LLMs*. *arXiv:2401.12273v2*. Available at: <https://arxiv.org/html/2401.12273v2> (Accessed: 31 July 2025).
- Li, J. and Wang, L. (2023). 'Integrating Artificial Intelligence into Higher Education: A Pathway to Education 4.0'. *International Journal of Educational Technology in Higher Education*, 20(1), 1-15.
- Liang, J., Stephens, J. and Brown, G. (2025). A systematic review of the early impact of artificial intelligence on higher education curriculum, instruction, and assessment. *Frontiers in Education*, 10. Available at: <https://doi.org/10.3389/feduc.2025.1522841> [Accessed 1 Aug. 2025].
- Liao, Z., Antoniak, M., Cheong, I., Cheng, E.Y.-Y., Lee, A.-H., Lo, K., Chang, J.C. and Zhang, A. (2024). LLMs as Research Tools: A Large-Scale Survey of Researchers' Usage and Perceptions. *arXiv preprint arXiv:2411.05025*. Available at: <https://arxiv.org/abs/2411.05025> [Accessed 1 Aug. 2025].
- Lin, Y. (2025). 'AI Large Model Leaderboard: Alibaba Cloud Qwen2.5-Max Ranks at the Top', *AGI Creator*, 6 February - <https://agi-creator.com/2025/02/06/ai-large-model-alibaba-qwen2-5-max/> (accessed 18 March 2025).
- Lury, C. (2021.) *Problem Spaces: How and Why Methodology Matters* London: Polity Press.
- Mah, D., Knoth, N. and Egloffstein, M. (2025). Perspectives of academic staff on artificial intelligence in higher education: exploring areas of relevance. *Frontiers in Education*, 10, Article 1484904.

- Medikepura Anil, A. (2025). 'Technology convergence is leading us to the fifth industrial revolution'. *World Economic Forum*. - <https://www.weforum.org/stories/2025/01/technology-convergence-is-leading-the-way-for-accelerated-innovation-in-emerging-technology-areas/> (accessed 18 March 2025).
- Ministry of Education. (2025). 'China advances AI curriculum to cover full basic education'. *english.scio.gov.cn*, 13 May. Available at: http://english.scio.gov.cn/pressroom/2025-05/13/content_117871666.htm (Accessed: 30 July 2025).
- Müller, M., Chen, Y., Al-Khatib, L. and Singh, R. (2025). Responsible integration of generative AI in academic writing: A narrative review and synthesis. *Journal of Academic Integrity and Machine Learning in Education* - <https://journal.hmjournals.com/index.php/JAIMLNN/article/download/5729/3645/9643> [Accessed 1 August 2025].
- Naveed, H., Khan, A., Qiu, S., Saqib, M., Anwar, S., Usman, M., Akhtar, N., and Mian, A. (2025). 'A Comprehensive Overview of Large Language Models'. arXiv.(Cornell University) - <https://arxiv.org/abs/2307.06435> (accessed 18 March 2025).
- Nohria, N. (2021). *What the Case Study Method Really Teaches*, Harvard Business Publishing - <https://hbsp.harvard.edu/inspiring-minds/what-the-case-study-method-really-teaches> (accessed 22 May 2025).
- Oyetade, K., & Zuva, T. (2025). Advancing Equitable Education with Inclusive AI to Mitigate Bias and Enhance Teacher Literacy. *Educational Process: International Journal*, 14, e2025087. <https://doi.org/10.22521/edupij.2025.14.87>
- Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage Publications.
- Peláez-Sánchez, I. C., Velarde-Camaqui, D., and Glasserman-Morales, L. D. (2024). 'The impact of large language models on higher education: exploring the connection between AI and Education 4.0.' *Frontiers in Education* - <https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2024.1392091/full> (accessed 15 May 2025).
- Pew Research Center (2021). 'Worries about developments in AI'. *Pew Research Center*. Available at: <https://www.pewresearch.org/internet/2021/06/16/1-worries-about-developments-in-ai/> (Accessed: 31 July 2025).
- Rogers, J. (2000). 'Communities of Practice: A framework for fostering coherence in virtual learning communities'. *Educational Technology & Society*, 3(3), 384-392.
- Sallam M. (2023). ChatGPT Utility in Healthcare Education, Research, and Practice: Systematic Review on the Promising Perspectives and Valid Concerns. *Healthcare (Basel)*.;11(6):887. doi: 10.3390/healthcare11060887. PMID: 36981544; PMCID: PMC10048148.

- Shahzad, T., Mazhar, T., Tariq, M.U., Ahmad, W., Ouahada, K. and Hamam, H. (2025). 'A comprehensive review of large language models: issues and solutions in learning environments', *Discover Sustainability*, 6(27). at: <https://link.springer.com/article/10.1007/s43621-025-00815-8> (accessed 19 May 2025).
- Singer, S. and Sheehan, M. (2025). China's AI Policy at the Crossroads: Balancing Development and Control in the DeepSeek Era. *Carnegie Endowment for International Peace* - <https://carnegieendowment.org/research/2025/07/chinas-ai-policy-in-the-deepseek-era?lang=en> [Accessed 1 Aug. 2025].
- Spours, K. (2024). From learning ecologies to a social ecosystem model for learning and skills. *Systems*, 12(9), p.324. DOI: 10.3390/systems12090324
- Stake, R. E. (1995). *The art of case study research*. Sage Publications.
- State Council. (2025). 'New Education Development Blueprint Unveiled'. *Science and Technology Daily (stdaily.com)*, 12 February. Available at: https://www.stdaily.com/web/English/2025-02/12/content_294918.html (Accessed: 30 July 2025).
- The Straits Times. (2025). 'More universities in China regulate use of AI in writing'. *The Straits Times*, 27 March. Available at: <https://www.straitstimes.com/asia/more-universities-in-china-regulate-use-of-ai-in-writing> (Accessed: 30 July 2025).
- Thormundsson, B. (2025). 'Large language models (LLMs) - statistics & facts', *Statista*, 24 February. - <https://www.statista.com/topics/12691/large-language-models-llms/> (accessed 18 March 2025).
- Tindall, R. (2024) 'What are China's new guidelines on AI regulation?', *China Britain Business Council*. Available at: <https://focus.cbbc.org/what-are-chinas-new-guidelines-on-artificial-intelligence-regulation/> (Accessed: 8 December 2024).
- Tredence. (2025). 'What Are Multimodal LLMs? Exploring the Next Evolution in AI'. *Tredence Blog*, 3 January. Available at: <https://www.tredence.com/blog/multimodal-llm-models> (Accessed: 30 July 2025).
- UNESCO IESALC. (2025). *The Role of Higher Education in National Artificial Intelligence Strategies: A Comparative Policy Review*. Available at: <https://www.iesalc.unesco.org/en/articles/role-higher-education-national-artificial-intelligence-strategies-comparative-policy-review> (Accessed: 29 July 2025).
- University of Oxford. (2023). 'Tackling the ethical dilemma of responsibility in Large Language Models'. *University of Oxford News*, 5 May. Available at: <https://www.ox.ac.uk/news/2023-05-05-tackling-ethical-dilemma-responsibility-large-language-models> (Accessed: 31 July 2025).
- Upadhyay, A., Farahmand, E., Muñoz, I., Akber, M. and Witte, N. (2024). Influence of LLMs on Learning and Teaching in Higher Education SSRN - <https://ssrn.com/abstract=4716855> or <http://dx.doi.org/10.2139/ssrn.4716855> (accessed 19 May 2025).

- Wang, S., Xu, T., Li, H., Zhang, C., Liang, J., Tang, J., Yu, P.S. and Wen, Q. (2024). 'Large Language Models for Education: A Survey and Outlook'. *arXiv:2403.18105*. Available at: <https://arxiv.org/pdf/2403.18105> (Accessed 22 May 2025).
- World Economic Forum (2023). *The Future of Jobs Report 2023*. Available at: https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf (Accessed: 31 July 2025).
- World Economic Forum (WEF) (2025). *AI geopolitics and data centres in the age of technological rivalry*. Available at: <https://www.weforum.org/stories/2025/07/ai-geopolitics-data-centres-technological-rivalry/> (Accessed: 1 August 2025).
- Williams, R. (2023). The ethical implications of using generative chatbots in higher education. *Frontiers in Education*, 8, Article 1331607.
- Yan, L., Sha, L., Zhao, L., Li, Y., Martinez-Maldonado, R., Chen, G., Li, X. and Gašević, D. (2023). 'Practical and ethical challenges of large language models in education: A systematic scoping review'. *arXiv preprint arXiv:2303.13379* - <https://arxiv.org/abs/2303.13379> (accessed 22 May 2025).
- Yang, Q., Zhang, Y., and Li, X. (2023). 'Ethical and fairness concerns in LLMs'. *Ethics in AI*, 18(2), 201-214.
- Yin, R. K. (2018). *Case study research and applications: Design and methods*. Sage Publications.
- Yin, Ruizhi. (2024). 'Advantage of Chinese AI in large language models versus the US'. *ThinkChina*. - <https://www.thinkchina.sg/technology/advantage-chinese-ai-large-language-models-versus-us> (accessed 15 May 2025)
- Zhang, L., Li, Y. and Wang, Q. (2023a). 'AI in Education: Current Trends and Future Directions in China'. *International Journal of Artificial Intelligence in Education*, 33(4), 801-815.
- Zhang, A.H. (2024). 'The Promise and Perils of China's Regulation of Artificial Intelligence', *Columbia Journal of Transnational Law* - <https://www.jtl.columbia.edu/volume-63/the-promise-and-perils-of-chinas-regulation-of-artificial-intelligence> (accessed 1 August 2025).
- Zhang, X., Li, D., Wang, C., Jiang, Z., Ngao, A. I., Liu, D., Peters, M. A., and Tian, H. (2023b). 'From ChatGPT to China' Sci-Tech: Implications for Chinese Higher Education'. *Beijing International Review of Education*, 5(3), 296-314.
- Zhang, Y., Chen, Y., and Li, X. (2023a). 'Accuracy and robustness of Chinese LLMs'. *Journal of Artificial Intelligence*, 27(5), pp. 456-470.
- Zhang, Y., Li, N. and Wang, X. (2023b). 'China Education Modernization 2035: A Strategic Plan for Educational Transformation'. *Journal of Educational Policy*, 38(6), 789-803.