ChatGPT and its impact on research supervision: Insights from Australian postgraduate research students

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As artificial intelligence (AI) continues to evolve, its impact on academic environments, especially in postgraduate research supervision, becomes increasingly significant. This study explored the impact of ChatGPT, an advanced AI conversational model, on five dimensions of research supervision: functional, enculturation, critical thinking, emancipation and relationship development. Using a qualitative approach, we examined the practices and perspectives of 20 postgraduate research students with at least 4 months' experience of using ChatGPT in research activities in Australia. The study revealed several areas of impact, including accelerated research progress, enhanced research quality, improved scholarly development and professional skills, enhanced critical thinking, increased student confidence and autonomy, and a deeper supervisory relationship. The findings suggest a shift in the roles and responsibilities of supervisors and students: the former provides strategic direction and high-level guidance, while the latter transits from apprentices to autonomous researchers due to the independence fostered by ChatGPT. This shift suggests an evolving model of postgraduate research supervision, with educational technology acting as epistemic tools to enhance the supervisory process. The study also considers the ethical implications of AI-enabled support.

Implications for practice or policy:
- Postgraduate students can be facilitated by ChatGPT in self-directed research for enhanced independence and autonomy.
- Supervisors can deploy supervisory meetings for high-level guidance and personalized feedback in an AI-enhanced supervision model.
- Postgraduate programmes can leverage generative AI tools for an AI-enhanced research supervision model.
- Universities need to develop AI literacy curricula and protocols to guide students towards responsible use of generative AI tools while addressing potential challenges.

Keywords: ChatGPT, generative artificial intelligence, research supervision, postgraduate students, qualitative

Introduction

Since its release in December 2022, ChatGPT has made significant inroads into the global higher education sector (Dai et al., 2023; Rudolph et al., 2023). There has been an unprecedented surge in its adoption across universities and colleges, as reported by both mainstream news outlets and academic publications (similarweb, n.d.). A diverse range of students, spanning undergraduate and postgraduate levels, have been leveraging this advanced artificial intelligence (AI) tool to aid their academic pursuits (Strzelecki, 2023). Supporters of ChatGPT laud its potential as a powerful educational tool and believe that it offers a wealth of opportunities to enhance students' academic experiences with personalised, interactive and responsive supports. Alongside its promising advantages, several concerns have also emerged, such as academic integrity and data privacy (King & ChatGPT, 2023; Study.com, 2023). As this new technology has

increasingly been incorporated into students' daily academic practices, it becomes more urgent to empirically investigate its impact in the academic context and to capture its benefits and limitations as perceived by the stakeholders.

A significant number of ChatGPT users in higher education are engaged in postgraduate research under the supervision of faculty staff (Li et al., 2023). These students, often involved in complex and specialised fields of study, require extensive support in conducting in-depth research and developing sophisticated academic outputs (Bastalich, 2017). However, there may be various challenges in postgraduate research supervision, including supervisors' limited availability and a lack of timely communication and support for students (Halse & Malfroy, 2010). To address these challenges, technology-enabled supports, such as digital management systems and blended supervisory models, have been adopted in the supervisory process (Wisker et al., 2021). In this regard, ChatGPT, given its capability in processing some cognitive tasks that used to be exclusive to humans, may lend itself to further address these challenges.

Against this background, this paper presents a qualitative study about the impact of ChatGPT in postgraduate research supervision. The primary goal of this research was to explore how ChatGPT affects the dynamics of the research supervision process and the role of supervisors and supervisees. Based on the theoretical framework of research supervision proposed by Lee (2008), we examined five aspects of the supervision – functional, enculturation, critical thinking, emancipation and relationship development. We conducted in-depth interviews with postgraduate students majoring in a variety of disciplines to elicit their perspectives of and experiences with ChatGPT. By analysing the practice and pattern of student engagement with ChatGPT, we sought to uncover its impact on the supervisory dynamics and supervisor-supervisee relationship. The research findings may lead to a better understanding of how emerging technologies can be leveraged to support postgraduate students' unique challenges and further transform the landscape of research supervision in higher education.

Literature review

Postgraduate research supervision

Postgraduate research supervision has long been a significant topic in higher education (Bastalich, 2017). Postgraduate research students are individuals who have completed their bachelor's degree and are pursuing advanced study beyond the undergraduate level. These students are typically engaged in a master's or doctoral (PhD) programme, where the focus is on conducting original research in a specific field or discipline. In contrast to students in a coursework-based taught programme, postgraduate research students spend most of their time working on academic research under the guidance of a supervisor or a team of advisers. Depending on the discipline, students work either on a self-initiated independent research project or part of a large project in a research laboratory or team.

Research supervision is usually an intensive and multifaceted process (McCallin & Nayar, 2012). The guidance provided by supervisors to students often includes developing fundamental research skills and employing Socratic questioning in research as well as additional scholarly pursuits such as attending conferences (Mouton, 2001). According to Lee (2008), research supervision can be conceptualised with five aspects:

- Functional: focuses on the professional management of research project and progresses, which is often achieved through regular meetings, milestones and periodic outputs such as presentations in academic conferences and publications.
- Enculturation: concerned with the development of students' sense of belonging and becoming a member of the disciplinary community; it often involves student gains of disciplinary practices, such as ways of investigating, talking and writing as shared in a particular scholarly community.

- Critical thinking: concerned with the development of students' intellectual rigor, to think in new ways, to analyse and recognise flaws in arguments and to question and reflect on their own work.
- Emancipation: focuses on enabling students to become autonomous by supporting them in discovering personally meaningful frameworks, reframing who they are and transforming themselves.
- Relationship development: concerned with caring and loving and emphasises the social and emotional connections between supervisors and supervisees.

In regard to the five aspects, supervisors and students are engaged in frequent communication to enact the supervisory process (Lee, 2008). However, research supervision is often full of tensions, as it demands a considerable amount of time and attention to effectively guide students through their academic pursuits (Halse & Malfroy, 2010). Supervisors are frequently burdened with multiple responsibilities, including administrative duties and research endeavours, leading to a potentially overloaded schedule that could compromise the quality of their supervision (Vassil & Solvak, 2012). This tension creates a challenging environment, leading to potential problems such as extended completion times due to insufficient guidance for efficient progress (Bastalich, 2017). Besides, the time and workload pressure may push supervisors more into the functional and technical aspect of supervision, while ignoring social and emotional support to students; it can increase the likelihood of student disengagement and subsequent dropout (Van de Schoot et al., 2013). Given these challenges, educators and researchers have explored various administrative, management and technological solutions (Bastalich, 2017).

Technology-enabled support for postgraduate research supervision

To address supervisory challenges, digital technologies and technology-enhanced learning environments have been introduced to the management and support systems of postgraduate students (Gray & Crosta, 2019; Maor et al., 2016). Crossouard (2008) found that an online environment based on discussion forums can facilitate the feedback provision by supervisors and support doctoral students' research engagement. de Beer and Mason (2009) proposed a blended approach that integrates face-to-face meetings and a web-based platform to support communication in and assessment of research supervision and enhance the presence of supervisors over geographic barriers. The recent COVID-19 pandemic has propelled online and remote supervision into the forefront of research supervision (Wisker et al., 2021). Technologies such as videoconferencing, collaborative document editing and asynchronous communication platforms allow for a seamless transition to remote supervision (Phillips et al., 2021; Rasool et al., 2022). Such supervision models can not only enhance accessibility, inclusivity and flexibility but also present challenges such as technical difficulties, lack of face-to-face interaction and the need for advanced digital literacy (Gray & Crosta, 2019).

A literature review shows that most of the existing technology-enabled support appears to focus on the functional aspects of postgraduate research supervision – to streamline the administrative and communicative activities. The emphasis is primarily on procedural aspects and logistics, such as scheduling meetings, sharing documents and tracking progress. The intellectual and social aspects, such as critical thinking, enculturation and relationship development, seem to be less addressed. This could be primarily due to the inherent complexity and nuances associated with these aspects. Although traditional technology is often designed to provide information and process procedural tasks, these tools usually lack the adaptive and intuitive capacities necessary to promote higher-level thinking skills, offer cultural insights and foster social bonding.

The recent advent of AI like ChatGPT may offer the potential to address these issues. ChatGPT is an AI chatbot that can generate text-based responses to human inputs in natural language and process other types of inputs and outputs, such as statistical data and computer programmes (Bubeck et al., 2023). At the foundational level, ChatGPT is a large language model that has been trained with a large volume of quality data and fine-tuned through the reinforcement of learning from human feedback (Christiano et al., 2017). Educators argue that ChatGPT has been bringing sustainable changes to the teaching, learning

and assessment in higher education (Rudolph et al., 2023). Specifically, ChatGPT may be used to facilitate automated assessments and adaptive feedback, personalise education experiences, stimulate learners' curiosity and increase their engagement (Moore et al., 2022; Sallam, 2023; Wang et al., 2023). Considering the potentials, Dai et al. (2023) proposed an AI-enhanced learning model where ChatGPT can serve as an enabler for student learning. In this model, ChatGPT can be utilised to enhance learning analytics, scaffold students' ideation and learning, provide customised tutoring and feedback and monitor student process and performance.

Beyond educational activities, the potential of ChatGPT is also discussed in assisting with various research tasks (Rudolph et al., 2023). For example, ChatGPT is seen as helpful in streamlining the process of a literature review and providing concise summaries from a large volume of literature but the issue of authenticity remains a major challenge (Aydın & Karaarslan, 2022). It is also used as a brainstorming tool, generating innovative ideas and offering new perspectives for research topics (Dowling & Lucey, 2023). In terms of drafting and editing academic papers, ChatGPT has demonstrated its capability to assist in drafting sections of research documents and refining written content (Pavlik, 2023). Some educators argue that the incorporation of ChatGPT into postgraduate research activities may redefine the traditional supervisory process (Van Dis et al., 2023).

Despite the potential impact, it remains largely unknown how postgraduate research students respond to ChatGPT and its impacts on the research supervisory process. Although postgraduate students are increasingly adopting this new technology, we need more comprehensive knowledge about their utilisation strategies and the subsequent impacts on their research progression and quality. Against this background, our study addressed the following research questions:

(1) How do postgraduate research students use ChatGPT in their research activities?
(2) How does ChatGPT impact the research supervisory process?

Methods

Participants and research contexts

Participants were drawn from students enrolled in the Master of Philosophy (MPhil) and Doctor of Philosophy (PhD) programmes in a research university in Australia, due to their research-focused nature and the component of research supervision within these programmes. An open-call email was sent across the university, and snowball sampling was also used to ask recruited subjects to assist in recruiting additional subjects. The criteria for inclusion were (a) students who were studying in either MPhil or PhD programmes; (b) students who had at least 4 months' experience of using ChatGPT in their research activities; (c) the sample included a balanced distribution in terms of gender and academic disciplines. The university had issued guidance on ChatGPT and generative AI, primarily tips and best practices; the formal guidance of academic integrity was still under review, and Turnitin was adopted to detect AI-generated texts in student assignments.

A total of 20 postgraduate students were recruited for the study. Among the participants, seven students were enrolled in MPhil programmes, while 13 were pursuing PhD programmes. The gender distribution was evenly split, with 10 male and 10 female students. In terms of majors, 13 students were engaged in the fields of science, technology, engineering, and mathematics (STEM), while the remaining students represented humanities and social science disciplines, including arts, linguistics, education, business and sociology. Each subject was compensated for their time and participation in the study. Ethical approval for this study was obtained from the affiliated university, and informed consent was gained from all the subjects before the study.

Data collection

Semi-structured interviews were conducted to gain an in-depth understanding of students' perspectives of and experiences with ChatGPT in June 2023. The interview comprised two major components: students' use of ChatGPT in their research projects and the impact of ChatGPT on the research supervisory process. Informed by Lee's (2008) framework, an initial list of interview questions was developed, but the framework was not strictly adhered to. Example questions included "On what research tasks do you use ChatGPT?", "Did your use of ChatGPT change your project progress, if yes, how does it happen?", "Did the use of ChatGPT change the way you engage with your research project or supervisor? If yes, how did that happen?" Each interview lasted between 1.5 and 2 hours. The interview was audio-recorded and transcribed verbatim.

Student conversation records in ChatGPT were collected to scrutinise their authentic practices and perspectives. The conversation records represent a kind of digital artefact that documents the authentic exchange between human users and ChatGPT, which can be shared with the third party via a link (OpenAI, n.d.). Each subject was requested to provide five pieces of the conversation records about their research projects for data analysis. The conversation records were referenced in the interview in a stimulus-recall manner: When the subject was interrogated about their experiences with ChatGPT, the interviewer cross-referred with the records for confirmation and clarification (Dempsey, 2010).

Data analysis

The collected data was analysed with a thematic analysis method (Braun & Clarke, 2006) to identify, analyse and report patterns or themes regarding the impact of ChatGPT in postgraduate research supervision. The analysis was informed by Lee's (2008) theoretical framework of research supervision, as we constantly referred to the five aspects of research supervision in reviewing, coding and analysing the data. To begin with, we (two trained researchers) thoroughly familiarised themselves with the interview transcripts. We independently read the transcriptions and conducted open coding, where we categorised the data and generated initial codes accordingly (Glaser, 2016). Concurrently, we kept theoretical memos, documenting their reflections, questions and preliminary interpretations (Glaser & Strauss, 2017). From the initial codes, we further explored salient patterns and identified potential themes. Regular discussions were held to compare, contrast and refine the initial themes. Then, we shared the initial themes, codes and memos with the other members of our research team for collective review and discussion. This process was characterised by iterative revision and refinement of the constructed themes, leading to the final thematic categories.

To enhance the validity and reliability of the data analysis and interpretation, triangulation was adopted (Patton, 1999). Specifically, analyst triangulation was used, which involved the participation of multiple researchers in the data collection and analysis process. Besides, data triangulation was also used, where interview transcripts and conversation records were juxtaposed to validate the data analysis and interpretation. Moreover, the research findings were communicated with the research subjects to confirm the accuracy of data interpretation.

Findings

The research findings are presented in three parts. First, we present an overview about student use of ChatGPT in postgraduate research context. Second, based on student practices and perspectives, we analysed how the use of ChatGPT impacted the research supervisory process. Finally, we investigated the evolving role of supervisors and students in the ChatGPT-mediated research supervisory process.

An overview of ChatGPT-enabled support in students' research activities

The analyses of student interviews reveal seven categories of research tasks for which students used ChatGPT, as shown in Figure 1. The most common tasks among the interviewed students were

personalised tutoring and explanation. In using ChatGPT for personalised tutoring and explanation, students often gave explicit instructions and directly asked ChatGPT to answer certain knowledge-based questions or explain something. In doing so, students referred to ChatGPT as a "knowledgeable assistant" who could teach and communicate complex, difficult ideas in comprehensible language. The second common task was language editing and proofreading. For this task, ChatGPT was used to not simply polish or proofread given texts but to search for and recommend phrases or sentence structures to express given meaning in academically professional ways. The third most common task was to facilitate students' brainstorming and ideation. In this task, students often started with introducing their research ideas or planning and asked ChatGPT if there were any other perspectives to enrich or challenge the plan.
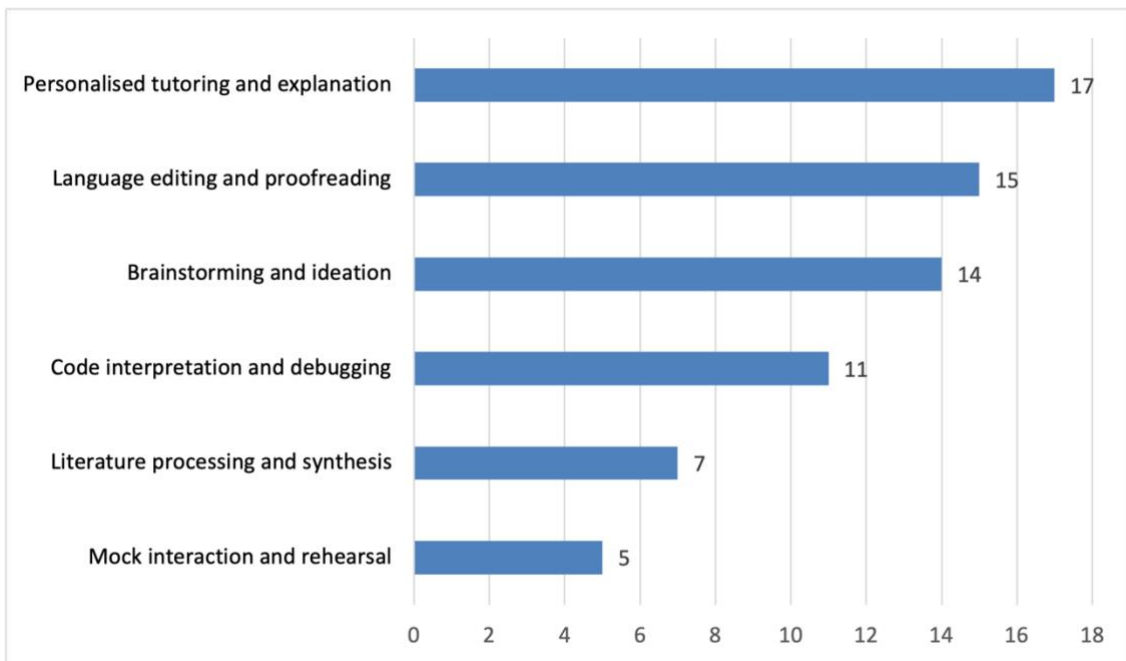

Figure 1. Frequency of student engagement in different research tasks with ChatGPT

The fourth and fifth common tasks were literature processing and synthesis and code interpretation and debugging. In both tasks, ChatGPT was used as an "expert reader" who can process given texts and codes and generate summaries or reports. Although the literature processing task was mostly undertaken by students majoring in humanities and social sciences, code interpretation and debugging was primarily used by the STEM students. All these students seldom directed ChatGPT to generate a literature review about a given topic but rather used it to process and synthesise identified articles or literature. The last common task was mock interaction and rehearsal, where students assigned ChatGPT a certain role (e.g., the supervisor or lab colleagues) and instructed ChatGPT to respond to their research presentation as if in "mock meetings".

The investigation on student adoption of ChatGPT in their postgraduate research also revealed a pattern of learning by using. Although students' conceptions of ChatGPT varied, they gained more understanding about the capacities of ChatGPT during their interaction with it and developed practices that were tailored to their individual research needs. Almost all the students mentioned the issues of authenticity and accuracy in responses generated by ChatGPT, especially when it came to literature and resource searching. In responding to the issues, some students directly stopped using ChatGPT for such tasks; other students, while still using it for such tasks, applied critical inquiry strategies such as cross-validation of information sources to ensure the credibility of the AI-generated responses. As the students acquired a deeper understanding of ChatGPT, their practices reflected an adaptive nature; they adjusted their strategy of inquiry with ChatGPT to meet their personal research needs.

Impact of ChatGPT on the supervisory process

Based on the findings of student practices and accounts, we further identified the impact of ChatGPT in the five aspects of the research supervisory process used by Lee (2008). Each aspect is elaborated with thick descriptions of student practices and accounts.

Accelerating research progress and improving the quality of research projects
The analyses show that the impact of ChatGPT was most pronounced in the functional aspect of research supervision, especially regarding the advance of students' research projects and milestones. The participating students generally reported improved efficacy of their research engagement, where their progress accelerated with higher quality. Most of the postgraduate students, for most of the time, were engaged in self-directed research either independently or in collaboration with lab colleagues and they presented their periodic progress to supervisors in individual meetings or lab meetings for feedback and guidance. The students attributed the accelerated progress to the personalised, simultaneous support from ChatGPT during their self-directed research, and more focused, specific guidance from their supervisors during the supervisory meetings.

During the self-directed research, many students reported using ChatGPT to help with entry-level, technical-oriented research work. For example, students instructed ChatGPT to explain difficult concepts or theories or sought feedback about their research ideas. Such engagement would have otherwise required them to consult with their supervisors or senior laboratory members, which often involved long waiting time and slowed down the research pace. Serving as a readily available intelligent tool, ChatGPT enabled a shorter feedback loop with more timely responses, through which students were empowered to overcome knowledge gaps and technical hurdles independently. For example, a student explained in the interview:

> For instance, reckon it's the middle of the night, like 2am or 1am, and I want a bit of advice, I can just ask ChatGPT, right? … The content of my chats with my supervisor, the progress I report can be more substantial … Take for example a previous paper of mine, I might have had to spend a good half a year prepping, but now a paper might just take about 2 months to knock out.

The interview shows that the timely responses and feedback from ChatGPT helped students engage with their research tasks with more efficacy and producibility. Since many of their entry-level technical problems could be effectively resolved with the help of ChatGPT, supervisors were then able to focus on more high-level guidance and mentoring and contribute the limited time of meetings to more critical aspects of research projects, rather than answering repetitive or entry-level questions.

Additionally, many students leveraged ChatGPT to process time-consuming tasks, such as browsing lengthy documents, interpreting code,and editing language. For example, many students complained about their daily task of reading lengthy literature, technical reports or computer programmes. Especially for STEM students, their coding tasks, one of their daily tasks, often involved understanding, modifying and reusing pre-existing codes obtained from open-source platforms like GitHub. Considering the variable coding styles and programme structures, reading the codes line by line was extremely time-consuming. They used ChatGPT to digest complex code structures and generate summaries for a quick understanding, and based on this, they further revised the code for their own projects. By using ChatGPT as an "expert reader", students could quickly process information from lengthy, redundant documents and therefore advance their research pace and progress.

Modelling disciplinary practices and supporting students' scholarly development
Beyond the research projects, postgraduate research students are often expected to grow into researchers or members of a scholarly community – the enculturation of research supervision. The examination of student practices and accounts showed that they purposefully instructed ChatGPT to model the ways of reasoning, talking and writing as an expert in their fields, from which they learned the scholarly practices as members of academia.

Students used the purposeful strategy of role-playing in prompting ChatGPT to model disciplinary practices. This strategy was to assign ChatGPT a role of the researcher in their prompts, for example, "Now you are a researcher in the field of …". Students explained that, by doing so, they could engage ChatGPT to think, talk and act like a researcher or scholar, which modelled the disciplinary practices within the academic community. For example, a doctoral student majoring in law elaborated:

> The answers it [ChatGPT] gives you are pretty scholarly; they meet a set of standard requirements. It's as if you're guiding it to become a professional doctoral student in law, having it answer these questions, and then the answers it gives are quite professional.

These roleplay interactions with ChatGPT provided the students with a unique opportunity to observe and internalise academic practices and discourses, as if they were in an ongoing conversation with a fellow researcher. The AI was able to embody a type of "virtual mentor" through which they could learn the specific nuances and technical jargon associated with their field of study.

Students also reported using ChatGPT to assist their writing about academic papers, research proposals or thesis drafts. In this context, they requested ChatGPT to "act as a peer reviewer" or "take on the role of a thesis supervisor". This helped students in understanding the expectations of their academic community, while also enhancing their ability to self-evaluate their work. Some students studying social sciences, such as education and sociology, explained that they find theoretical critique highly challenging in academic writing. To resolve the difficulty, they asked ChatGPT "how to express the idea … in a humble but critical way in academic writing". Through these interactions, students learned not just the content of their research field but also the language, logic and critical thinking skills used within their academic community.

Additionally, ChatGPT was also utilised by the students to prepare for supervisory meetings and academic presentations such as rehearsals or mock interviews. They simulated a research report or presentation with ChatGPT, asking it to pose as the supervisor or lab colleague. According to the students, though formal communication and presentation of research projects are common practices in academia, they found it stressful, especially when being interrogated with probing questions. Under this circumstance, ChatGPT was used as a "sparring partner" by some students and provided a risk-free environment for the students to practise their oral presentations, anticipate potential questions and formulate articulate responses. Through the stimulus communication with ChatGPT, students were able to bridge the gap between their current understanding and the academic practices of their fields. It not only aided students in their individual academic journey but also transformed them from being learners to becoming members of scholarly communities.

Nurturing students' critical thinking
Critical thinking, another aspect of research supervision, is often seen as foundational for high-quality, independent research. Traditionally, promoting critical thinking is usually seen as the responsibility of supervisors. That is, a supervisor's role is not to provide answers but rather to pose questions and construct dialectic conversations that challenge students' understanding, assumptions and perspectives. Through the exchanges, students are encouraged to reflect on, explore and reformulate their thoughts, which ultimately leads to critical thinking. The analyses of students' mock interactions and resource searching with ChatGPT show that ChatGPT, to some extent, was able to complement the supervisor's role in helping students develop critical thinking.

As mentioned, students leveraged ChatGPT in preparing their formal meetings or research presentations to anticipate potential criticisms of or alternative perspectives to their research. In these mock interactions, they actively sought ChatGPT's feedback and critique of their work to challenge themselves. A student recalled his practices:

> Sometimes I feel like I'm getting more and more tunnel vision, you know? Because every day I'm stuck on my own topic, the articles I'm reading, the issues I'm wrapped up in, it all

comes back to my own project. But by having a yarn with ChatGPT, letting it play devil's advocate, it forces me to step out of my own head, and look at my research from a different angle. Yeah, it's like my third eye without human bias.

This student, with the help of ChatGPT, was able to challenge his own thinking process and step out of his comfort zone. In this iterative process of critique and revision, students were essentially engaging in a form of dialectic conversation, mirroring the supervisor-student interaction in a research setting. This encouraged students to confront and address potential weaknesses in their research, enhancing their capacity to think critically and strategically about their research. Specifically, the presence of ChatGPT as non-human was perceived as a unique advantage by the students, as it seemed to add a sense of fairness and trustworthiness to its response.

Some students also prompted ChatGPT to search for counterarguments and opposite stances. Many students acknowledged that traditionally the literature review process was daunting due to the vast amounts of research material available. This sometimes resulted in a peripheral or surface-level understanding, where critical arguments could be overlooked. However, ChatGPT, with its vast training data, could present multiple viewpoints and contradictory opinions, encouraging students to evaluate different perspectives and develop a balanced and well-informed understanding. As a result, it paved the way for students' deeper, more nuanced understanding of the topic, fuelling their ability to critically evaluate and synthesise complex information.

Enhancing students' confidence and autonomy
Emancipation is to empower students' personal growth and self-discovery towards becoming autonomous individuals. While adopting ChatGPT in their research work, many students became more confident about themselves and their research projects. Such growth in confidence could be credited to two kinds of support by ChatGPT. Firstly, students felt that their research work was backed up or cross-validated by the massive scholarly resources behind ChatGPT. Due to such intellectual support and feedback, they considered that the quality of their research output had improved as well, which instilled a sense of confidence and trust in their work. Secondly, the mock interactions and rehearsal around students' research presentations allowed them to prepare for supervisory meetings as well as potential challenges. The iterative interactions with ChatGPT, despite its limitations, imbued students with a greater sense of familiarity and control in their research. Such familiarity seemed to ease the usual tension and apprehension associated with formal presentations or high-stakes meetings, replacing it with a sense of confidence.

Further, the presence of ChatGPT as a supportive tool engendered a heightened sense of autonomy and agency among students. Multiple students reported experiencing a greater sense of control over their research projects: They no longer needed to passively wait for a response or guidance from supervisors or senior lab colleagues, but could harness and deploy ChatGPT for assistance, feedback and clarification. Some students even claimed that a boss-and-assistant or subordinate relationship between themselves and ChatGPT emerged, where they gained feelings of taking the initiative and leading their own projects. This perception of autonomy appeared to have a spiralling effect, prompting students to actively grow and cultivate their research projects. One student acknowledged: "I should have thorough understandings about my project if I want to deploy my personal assistant [ChatGPT] effectively." In this regard, the influence of ChatGPT appears to reinforce students' confidence and independence and fuelled their intrinsic motivation to conduct research. Throughout this process, students evolved from being dependent on external assistance to being autonomous researchers who took ownership of their work.

Forging a more personal, personalised supervisory relationship
The integration of ChatGPT into the research process catalysed a significant transformation in the supervisor-student relationship. Students became increasingly adept at handling basic, entry-level research tasks independently with ChatGPT, while the quality of their research outputs also improved. This advancement in student capabilities introduced a shift in the supervisory role. Supervisors were no longer burdened by the need to address basic research queries or language editing but found themselves

in a position to maximise their expertise. Supervisors could redirect their time and focus on high-level discussions. These interactions included nuanced explorations of theoretical constructs and strategic directions. The shifting role of supervisors was evident in a student's account:

> My supervisor's guidance is more about the big picture, pointing me towards topics worth my time, or telling me which ones are a dead end, or maybe even how to tackle a topic from a certain angle. A lot of this advice is based on his own experience and gut feeling, stuff only he could see. And this insight is gold. It can really lift the quality of your research in no time. But that's something GPT just can't teach you.

The quotation shows that the introduction of ChatGPT created space for more intellectually stimulating and substantial exchanges between the supervisor and student, which propelled the research work to a higher level of quality.

Interestingly, the frequency of supervisory meetings remained relatively consistent despite the integration of ChatGPT into the research process. This appears to be largely attributed to the supervisors' availability, which typically determined the frequency of these meetings. However, as ChatGPT helped free up some supervisory time, some students gained more opportunities to delve into more personal aspects of their research project. They could share their personal thoughts, perspectives and confusions about their research with their supervisors. Students saw these interpersonal exchanges as invaluable, as their supervisors could offer tailored feedback and suggestions for improvement. Moreover, this personal engagement fostered a deeper connection between the supervisors and their students. The supervisors' better understanding of the students' individual capacities, viewpoints and challenges enabled them to provide more personalised guidance, which was pivotal in shaping the students' research journey.

Conclusion and discussion

The research findings underscore the transformative potential of ChatGPT in the realm of postgraduate research supervision. The analyses of student practices show that ChatGPT could facilitate a myriad of research activities. This support was found helpful in advancing students' research progress and quality; supporting their scholarly development, critical thinking, confidence and autonomy; and forging a more personal and personalised supervisory relationship. The research findings offer implications for the research and practices of technology-enabled support for postgraduate research supervision.

ChatGPT and generative AI as an epistemic tool to aid research activities

Student engagement with ChatGPT in research tasks confirms the epistemic affordance of generative AI tools like ChatGPT in recent discussions (Alvarado, 2023; Goldberg, 2018). Traditional technology-enabled supervision primarily caters to ease administrative burdens and enhance supervisor-student communication, such as scheduling, online meeting, collaborative editing, and tracking progress (Halse & Malfroy, 2010). However, the findings from this study indicate that generative AI transcends these operational constraints, acting not just as a facilitative tool but also as an epistemic partner in the research journey. This duality can be seen in the way students incorporated ChatGPT into their daily research and scientific practices, ranging from as a "knowledgeable assistant" for code and literature processing to as an ideation tool for research design and hypothesis formation. In this way, ChatGPT and generative AI tools lend themselves to supporting high-order thinking and intellectual growth and stimulating creativity and problem-solving skills essential for academic research and knowledge generation. The integration of generative AI as an epistemic tool may further redefine the expectations of postgraduate research students' skill and competency sets. This change raises a demand for students to possess AI literacy and a deep understanding of how AI can augment their research in a responsible and ethical way (Boscardin et al., 2023; Cardon et al., 2023; Dai et al., 2023).

An evolving model of postgraduate research supervision

The integration of ChatGPT into the research supervisory process appears to have resulted in a significant reconfiguration of roles and responsibilities for both supervisors and students. Supervisors, traditionally tasked with guiding students through both the technical and complex facets of their research, shifted towards a more mentorship-based role. With the introduction of ChatGPT, students could independently tackle entry-level, technical research tasks, and therefore their request for supervisors' facilitation in these tasks was greatly reduced. Instead, their expectation for supervisors was inclined to higher-level, strategic guidance. From the students' perspective, the supervisory meetings became more efficient, where their interactions with supervisors were more productive and stimulating. Moreover, students saw more opportunities to receive personal and personalised feedback from supervisors, through which they were more likely to forge deeper connections and mutual understandings.

On the other hand, students saw their responsibilities increase, fostering a higher level of independence and confidence in their research engagement. By utilising ChatGPT, students were able to independently address a variety of tasks that were previously beyond their individual capabilities. Such student independence enabled by ChatGPT allowed for a more proactive and autonomous approach to postgraduate research, where students were to take ownership of their research, gaining confidence and motivation. Moreover, by addressing technical tasks independently, students had more time to engage in deeper critical thinking and plan for the bigger picture of their research project. The ChatGPT-assisted research process encouraged the transformation of students from being passive apprentices to autonomous researchers.
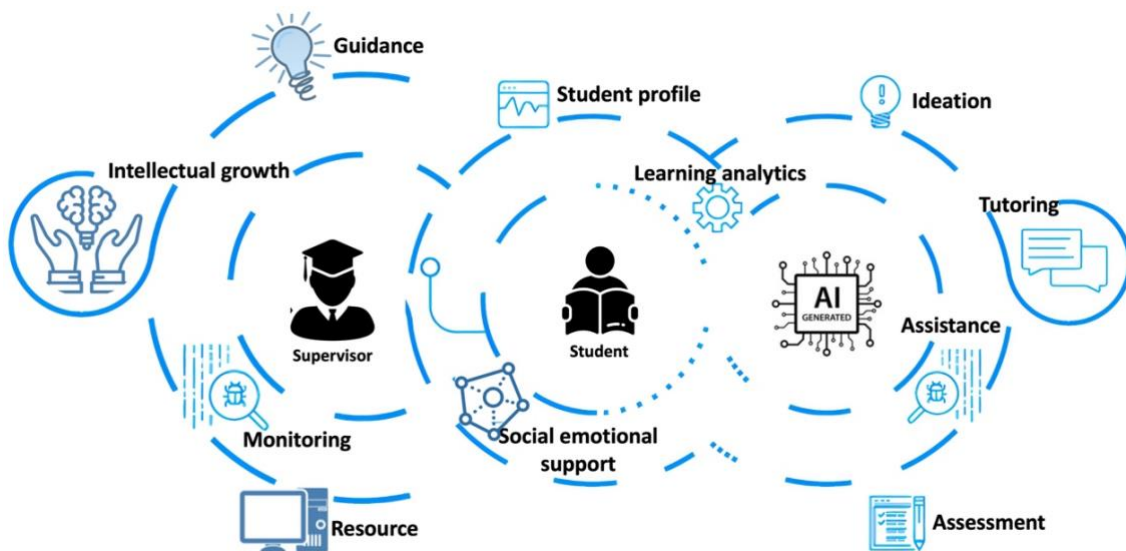

Figure 2. An AI-enhanced postgraduate research supervision model

The changing roles and responsibilities of supervisors and students implies an evolving model of postgraduate research supervision, as represented in Figure 2. This model is built upon the work of Dai et al. (2023) in conceptualising ChatGPT as an enabler in higher education. By applying and extending that model to postgraduate supervision, the present model includes three actors – the supervisor, student and AI – in the supervisory process. In this model, generative AI like ChatGPT can support students with routine, entry-level and technical-oriented tasks and immediate feedback. With such complementary support from AI tools, supervisors and students can focus more on the high-level, strategic and intellectual dimensions of research projects. In this way, human supervisors and AI work together, each playing to their strengths to provide the best support for postgraduate students.

Particularly, the integration of AI does not diminish the role of human supervisors. Instead, it brings the unique value of human supervisors into sharper focus and highlights their indispensable role. The fact

that AI can take over some routine, technical tasks echoes recent discussions that AI is predicted to free educators from routine tasks, allowing them to focus more on tasks that require human judgment and expertise (Bayne, 2015; Luckin, 2018). Under this circumstance, the intellectual, social and emotional support from supervisors becomes more important than ever. The supervisor's role evolves from being a broad knowledge provider to a focused facilitator of intellectual growth and resource provider. In this capacity, supervisors add the unique human values that AI currently cannot replicate, such as interpersonal mentorship, emotional support and context-specific insights.

Cautious and ethical concerns with AI-enhanced research supervision

Despite the significant support enabled by ChatGPT and AI tools, postgraduate programmes and supervisors should proceed with its adoption with caution. A significant concern is students' over-reliance on such technologies. The advent of AI in research can present an easy alternative that may deter students from engaging in hard, deep thinking and intensive intellectual labour. For example, while students intensively leverage ChatGPT to process literature and writing tasks, they might lose the first-hand experiences of processing texts and inhibit their further development in deep comprehension and written communication skills. In this regard, AI assistance may push research towards a mechanistic process, potentially hurting the process of students' intellectual and scholarly development. Therefore, it is important to strike a balance between utilising AI for productivity and preserving the integral human endeavours of research, which includes iterative ideation, investigation and communication of innovative knowledge.

Furthermore, ethical considerations surrounding the use of AI in academic contexts are crucial and yet still in nascent stages of understanding. As new tools such as ChatGPT are introduced, it becomes increasingly complex to define the boundaries of academic integrity and address potential instances of academic dishonesty. The use of AI raises concerns around plagiarism, authorship and inappropriate dependency. Moreover, the inherent bias in AI algorithms, issues of fairness and the potential for misuse are significant ethical dilemmas that need comprehensive discussion and resolution. As postgraduate students continue to integrate AI into research and academic practices, it is vital to develop robust ethical guidelines and safeguards to ensure the responsible and fair use of these powerful tools.

Limitations and future work

Although the findings from this research are encouraging, several limitations need to be acknowledged. First, the study predominantly relied on student interviews, leaving the perspectives of supervisors less explored. Future research could incorporate the views of supervisors to provide a balanced and comprehensive understanding of this research topic. Secondly, given the research scope, the study focused solely on students who had a minimum of 4 months' experience with ChatGPT, thus signalling their open and active attitudes towards novel technology. As such, the study did not capture the experiences of those less open or resistant to adopting AI technologies in their postgraduate research. Therefore, the findings might inherently favour the benefits and potential of ChatGPT, while the challenges, difficulties or potential resistance among less technologically inclined students remain unaddressed. Moreover, given that our study was conducted during a period when ChatGPT was relatively novel, longitudinal studies could offer deeper insights into the long-term implications of ChatGPT usage and the adaptability of both students and supervisors.

Author contributions

Yun Dai: Conceptualisation, Investigation, Writing – original draft, Writing – review and editing; **Sichen Lai:** Data curation, Investigation, Formal analysis, Writing – review and editing; **Cher Ping Lim:** Conceptualisation, Writing – review and editing; **Ang Liu:** Data curation, Writing – review and editing.

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