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INTRODUCTION

Artificial Intelligence (AI) use has become common in modern educational contexts. During a core course focused on Operating Systems fundamentals at the Southern Institute of Technology (SIT), students write, run, and debug small programmes that solve a series of simple computer laboratory exercises in Operating Systems management. The students commonly use a blend of course provided materials, Google searches, and ChatGPT or Microsoft Copilot, to support the efficient completion of these summative tasks. Institutional policy permits AI use if a declaration is completed, signed, and attached to the uploaded work. SIT, as a tertiary education provider, is keenly aware of the importance of work-readiness for its students and encourages the use of multiple approaches to problem-solving in the modern AI context. However, developing critical thinking skills and dispositions is also a key goal of this course and all undergraduate courses in Information Technology (IT) at SIT.

When student work has been outsourced to some extent to AI, students can often struggle to understand why the AI standard feedback and solutions work. They can display weak content knowledge of the programming concepts, especially during exams and other controlled assessment events. Their ability to think critically can also suffer. Gerlich (2025) states that "Critical thinking is a multifaceted cognitive process that involves the capacity to think clearly and rationally, understand logical connections between ideas, evaluate arguments, and identify inconsistencies in reasoning." (p. 3). Alsaleh (2020) found that "C[ritical T[hinking] can be defined as an individual thought process that begins with the intent to solve a problem or to answer a question, by examining different options and choosing the most suitable and logical one" (p. 21). Critical thinking is not only a set of skills that can be taught but requires an intention or disposition to pursue it. Notably, Tari and Rosana (2019) acknowledge "six capabilities (interpretation, analysis, evaluation, inference, explanation, and self-regulation), 16 sub-abilities, and 19 dispositions" (p. 4) related to critical thinking skills. Thus, critical thinking is vital for self-directed learning and the building of a student's intellectual independence.

If students are taught to explore the tensions between beneficial and problematic AI use, there is potential to develop their critical thinking skills, leading to enhanced work-readiness in the IT industry. AI provides many benefits to students including reduced cognitive load, increased productivity, and enhanced self-sufficiency (Choudhuri et al., 2024). However, AI creates some challenges for students including cognitive offloading, reduced skill retention, and excessive and often uncritical reliance on the outputs of such systems (Shen & Tamkin, 2026). In addition, Zhang et al. (2024) explored AI dependency and factors which represented problematic AI usage,

including laziness, the disseminating of misinformation, and reduced critical thinking. This reflective piece aims to explore some benefits and some challenges of AI in relation to the development of critical thinking for IT students. Consideration of underlying educational assumptions which inform teaching practices, and the interplay between AI use and critical thinking, will be related to practical classroom teaching.

CONTEXT

The context under consideration involves adult learning in a tertiary education setting. A formal, structured teaching approach, informed by the principles of andragogy and complemented by the affordances that heutagogy provides for online learning, forms the pedagogical foundation of this reflective piece. Andragogy as a theory of adult learning typically includes a set of assumptions about how adults, as distinct from children, learn. Andragogy typically assumes, for instance, that learners are self-directed, draw on accumulated experience, possess a readiness to learn, and desire immediacy and relevance in knowledge that can be applied to solve problems and increase internal motivation to continue learning (Loeng, 2023, p. 41). Heutagogy as an adult learning theory is described as "an extension of andragogy's reinterpretation, and perhaps the distinction is the same problem when one visibly attempts to differentiate between pedagogy and andragogy" (Lapele et al., 2022, p. 155). Newfield (2025, p. 1) argues that "Heutagogy, or self-determined learning, is an innovative educational approach emphasizing learner agency, autonomy, and a continuous, self-directed learning process." As such, heutagogy emphasises improvement in learning how to learn, non-linear approaches, and double-loop learning, where the learning contexts blend formal and informal aspects and students decide what and when to learn. SIT students include younger adults and older mature learners, and AI use via online resources has become commonplace amongst both these cohorts. Thus, at SIT, in the context of the Operating Systems Management course, students exercise the freedom to mix and match AI use on campus and off-campus, to find unconventional ways of getting their work done, and complement classroom work with personal research and experimentation.

AI: HELPING CRITICAL THINKING

When students are completing summative assessments, the stakes are higher than those for formative assessments. Given that time constraints apply to all summative work, students are necessarily motivated to seek out tools to increase their productivity and reduce the cognitive effort required to complete such tasks. Choudhuri et al. (2024, p. 3) found that students interacting with conversational agents such as ChatGPT during software engineering tasks reported a lower cognitive load than students who used alternative resources. Also, the authors found ChatGPT positively affects students' productivity and self-efficacy. The students were able produce working results quickly, with less mental effort and with more independence from the teacher. The operating systems tasks involved problems to solve, the examination of different solution options for the programming tasks, and choosing the solution most suitable to the set task. So, in this respect, AI use somewhat supports limited critical thinking which aligns with the Alselah (2020) definition. However, the deeper criteria of the Gerlich (2025) critical thinking definition would not seem to be met with this task in this context.

Shen and Tamkin (2026) found distinct AI interaction patterns on programming tasks involving generation of possible solution options, prompted explanations of why the solution worked,

efficient debugging, and evaluation of logic errors. The tasks required students to identify and diagnose code errors, explain how the code worked, and respond to questions about the programming concepts. This process aligns a little more closely with the ability to think logically through code generation, understand connections between ideas represented in programming principles, and evaluate the inconsistency of logic errors during debugging. AI in this setting is being used to help students to complete assessment tasks which have been designed to incorporate opportunities to develop critical thinking.

Moguš (2025) performed a systematic review of research between 2023 and 2025 related to the contribution that careful chatbot prompt engineering can make to the development of critical thinking skills in higher education. Moguš (2025) found that "well designed prompts essentially stimulate the higher-order cognitive processes, which are the ones that involve the critical thinking skills of analysis, creation, and reflective reasoning and also that they lead to increased engagement and metacognitive awareness" (p. 235). Students can use prompts to ask the chatbot for more detailed explanations of the solutions provided and prompt the chatbot to evaluate these solutions according to set criteria. However, this approach assumes that the student will know how to frame their prompts based on their existing content knowledge. As the student responds to the feedback provide by the chatbot, they naturally refine the wording of their inputs to get closer to their goal of task completion. Notably, Moguš (2025) also points out that content knowledge, critical thinking, and iterative design form the basis for effective chatbot prompt design. Therefore, some initial content knowledge and an ability or disposition to think critically acts as a starting point, from which the student can iterate and gradually build on their content knowledge and increase their levels of critical thinking. The chatbot interaction process is multifaceted, where non-linear phases of back-and-forth actions and responses also support experiential learning (Kolb & Kolb, 2017). Thus, students can use AI to support their critical thinking skills and dispositions through the rapid feedback provided by such systems, which can motivate them to keep asking questions and evaluating the outputs from their continually refined prompts.

AI: HINDERING CRITICAL THINKING

The use of AI tools such as chatbots to provide support to novice programmers in developing essential programming skills does raise some concerns about hindering students from improving their critical thinking skills. Zviel-Girshin (2024) studied AI tool usage during a first-semester introductory programming course and identified several key concerns including students' overreliance on the tool's capability, potentially leading to surface learning of programming concepts and reduced ability to solve problems independently. Surface learning and less independent thought would tend to undermine the rigour of critical thinking.

Other researchers highlight further concerns such as cognitive offloading. Bandam (2025) defines cognitive offloading as "the process by which humans delegate cognitive tasks to external tools or systems" (para. 2.) Unless a learner actively maintains skills, it is likely that they will degrade with time. Task delegation can introduce additional decision making to the AI user, so that they pay less cognitive attention to the deeper and more reflective demands of critical thinking. AI use can also hinder critical thinking due to the volume and scope of its feedback to the user, potentially generating more cognitive burden. Increased cognitive burden could lead to students taking shortcuts to their solutions and increasingly relying on AI, acting more like a skilled operator than an IT graduate with specialist problem-solving and critical thinking skills.

Gerlich (2025) studied the relationship between AI tool use and critical thinking skills and found "a significant negative correlation between frequent AI tool usage and critical thinking abilities, mediated by cognitive offloading" (p. 1). When learners rely excessively on AI technology to outsource cognitive tasks and blindly accept the outputs from such systems without critical evaluation, they may weaken their abilities to perform deep analysis. Also, since chatbots tend to continually generate output that is narrowly tailored to the user's prompts, it may close off learners to wider perspectives. Content that naturally aligns with the learner's beliefs may hinder them to engage with the multiple perspectives that critical thinking requires.

Work-ready students need to use AI as it increasingly becomes common in the modern workplace. However, wise use of AI, balanced by other methods that require personal cognitive engagement, is also important to mitigate the negative effects of AI tool use on students' critical thinking skills. AI output is often convenient to use and efficient in providing quick solutions to complex problems. However, this may obscure deeper learning approaches that typically involve critical thought. The Organisation for Economic for Co-operation and Development (OECD) explored effective use cases of Generative AI (Gen AI) in Education and found that "many students are clearly turning to Gen AI tools for academic purposes. However, their primary motivations often center on convenience and efficiency rather than deeper learning" (p. 16). This research also included teachers' opinions about AI making incorrect assumptions. Uncritical AI tool use may add an additional cognitive burden for students as they need to determine if an assumption is incorrect or not. If assumptions cannot be questioned or validated, the logic of argument, which underpins critical thinking, is likely to be weakened or invalidated.

OPERATING SYSTEMS CLASS

Having reviewed the interplay between AI use and critical thinking, this section contextualises these reflections in a practical classroom setting. The session occurred on a weekday afternoon in the computer laboratory with 20 students. The class consisted of young adults with varying prior knowledge of operating system programming. A broad student demographic, including international learners, was represented in the class. This presented an opportunity to draw on prior studies in programming as we navigated our way through the course. This variety of backgrounds informed my teaching of operating system administration in a personally relevant way. Some students might be revisiting semi-familiar material from their prior programming courses or work experience, or computing courses at secondary school. Older students would be returning to tertiary education after some years in the workforce and perhaps had never dealt with this topic in a tertiary academic setting. Those more familiar with IT and building software solutions would find the lab tasks less challenging than students who had only had prior academic exposure to programming. This was an opportunity to present the lab tasks and lecture material with a questioning approach, emphasising critical thinking from the beginning to enhance student engagement and stimulate curiosity. This would also make theory and practice more logically and personally connected. It was also a situation to appreciate the students' life experiences as a central part of the learning process in the classroom or laboratory.

The lab work was concerned with solving simple programming problems and some systems administration tasks working with the Linux operating system and its in-built scripting environment. This non-Windows operating system environment provided challenges to all students and somewhat levelled the playing field for the class. Students were able to use a broad range of resources including course materials, the internet, and AI tools to solve problems and support

their answers to set questions. AI chatbot use facilitated a sharing culture, where students would team up and help each other to find resources and solve problems.

The first section of the lesson involved explaining the lab tasks in enough detail so that the students could identify what resources they needed to complete the tasks. Apart from course materials and Google searches, these resources included ChatGPT and Microsoft CoPilot. The emphasis remained on students' needing to understand why their solutions worked. It was pointed out that the Linux scripting environment contains help facilities, although these are not user-friendly or intuitive to use when debugging errors in the students' programming code. Example programming code was walked through, and some limited live testing attempted. Some quiet class discussion developed, and students started working on their lab tasks. Students raised some brief questions about the need to comprehend the programming solutions to the lab tasks, and whether they would need to understand these solutions in a controlled practical test situation, which naturally led into the second part of the teaching session.

The second section involved the core learning activities for this lesson, which involved a set of lab tasks for which the students needed to develop working solutions and document their results. The tutor circulated in the lab to provide support to each student as they engaged in writing, testing, debugging, and finishing each task. Students who made frequent use of AI tools produced working results more quickly than students who used AI tools less. In rare cases, students elected not to use AI tools. Often students used AI tools in bursts of activity, for example following a hand code, a quick test, and a debug, with the use of AI tool to assist debugging and then more testing, in sequence. Notably, some AI solutions to the lab tasks exceeded the stated requirements in the assessment and included programming code techniques that had not been covered in their previous classes or been presented in this course.

Reflection on the literature and on my teaching practice revealed several key points. One such point was that students wished they had a better grasp of programming to solve the problems without having to outsource most of the cognitive effort required to complete the work. Another key insight was that students experienced rapid feedback and help from tools such as ChatGPT and it is likely that these AI tools had taught them something of value. However, the additional cognitive effort involved in formulating the right prompts to the AI tool, for instance to find out why the proposed solution did not work and what the errors meant during debugging, could demotivate students to expend extra effort in then applying critical thinking skills to the solutions produced.

The third and final section of the lesson involved the tutor's wrap-up summary of what tasks had been presented, giving an opportunity for students to share what they had learned and what they might need to work on for the next task that they were expected to complete. The tutor reinforced the need to understand the solutions that they had arrived at; not only that the solutions worked, but that the students had a grasp of the underlying programming code principles. The students were encouraged to always ask: why does a particular solution work or not work? Could I develop a different solution that would work equally well? Is my solution flexible so that it can be maintained for future use? Does the solution meet the set task requirements precisely? Such questions are important for IT students who need to become familiar with a customers' requirements in IT industry work contexts.

CONCLUSION

The research explored in this reflective piece suggests that, if students are taught to negotiate the tensions between beneficial and problematic AI use, there is potential to develop their critical thinking skills, enhancing their work-readiness in the IT industry. This article also highlights that the use of AI tools to solve programming problems can involve some aspects of critical thinking, if properly directed by educators. Deliberately guiding students in careful and critical use of AI offers a balanced way forward for academics to encourage students to develop critical thinking skills as they increasingly rely on AI and chatbots to solve problems (Zhang et al., 2024). Additionally, contextual teaching and learning is essential to develop critical thinking skills, and in wider terms involves constructivism, inquiry, questioning, learning community, modelling, reflection, and authentic assessment (Tari & Rosana, 2019).

We have briefly explored selected literature which cites AI use to support students' critical thinking. In contrast, we have also surveyed literature that raises significant issues around AI tools, such as where AI might hinder the development of students' critical thinking due to cognitive offloading. There is evidence that AI tools have ample potential to support students to enhance their critical thinking skills, but not without real, and sometimes far-reaching, costs if not used wisely.

It is important to point out that appropriate use of AI tools requires a student to have developed a certain prior level of critical thinking skills and some technical knowledge. There are also significant risks involved with reducing the technical competency of future IT workers from software engineers to AI tool prompt operators who lack deep content knowledge and a strong set of critical thinking skills. The potential for AI tool use to undermine critical thinking is also a significant risk to AI users if they practice overreliance, using AI too frequently and potentially weakening their disposition to remain critically aware and independently minded.

A balanced approach to using and continually evaluating AI tools will be important for the foreseeable future. AI tool usage needs to balance task automation with task augmentation, where AI tools support and extend human skills (Sabherwal & Grover, 2024). There has never been a greater need for educators to teach, promote, and foster critical thinking skills in their students and themselves. As tertiary educators in the AI era, our students have a powerful set of AI tools and may seem to be able to solve almost any problem presented to them. However, tutors need to deliberately teach and model critical thinking in action, support our students to develop strong academic identities, and to grow students' confidence in their own thinking. Thus, graduates will be able to use AI strategically to augment human skills rather than replace them, which is likely to result in cognitive atrophy and a loss of empowerment.

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REFERENCES

Alsaleh, N. J. (2020). Teaching critical thinking skills: Literature review. *The Turkish Online Journal of Educational Technology, 19*(1), 21–39. https://files.eric.ed.gov/fulltext/EJ1239945.pdf

Bandam, R. (2025). *Cognitive offloading: How AI is quietly eroding our critical thinking*. IEEE Computer Society. https://www.computer.org/publications/tech-news/trends/cognitive-offloading

Choudhuri, R., Liu, D., Steinmacher, I., Gerosa, M., & Sarma, A. (2024, April). How far are we? The triumphs and trials of generative AI in learning software engineering. In *Proceedings of the IEEE/ACM 46th International Conference on Software Engineering* (pp. 1–13).

Gerlich, M. (2025). AI tools in society: Impacts on cognitive offloading and the future of critical thinking. *Societies, 15*(1), Article 6. https://doi.org/10.3390/soc15010006

Kolb, A. Y., & Kolb, D. A. (2017). Experiential learning theory as a guide for experiential educators in higher education. *Experiential Learning & Teaching in Higher Education, 1*(1), 7–44. https://nsuworks.nova.edu/elthe/vol1/iss1/7

Lapele, F., Kartowagiran, B., Haryanto, H., & Prihono, E. W. (2022). Heutagogy: The most holistic approach utilizing technology in learning. In *5th International Conference on Current Issues in Education (ICCIE 2021)* (pp. 154–159). Atlantis Press.

Loeng, S. (2023). Pedagogy and andragogy in comparison – Conceptions and perspectives. *Studies in Adult Education and Learning, 29*(2), 39–52. https://doi.org/10.4312/as/11482

Moguš, A. M. (2025). Using prompt engineering to foster critical thinking in higher education. In *Proceedings of the 16th International Conference on e-Learning* (pp. 235–244). Belgrade Metropolitan University, Serbia. https://doi.org/10.46793/eLearning2025.235MM

Newfield, T. (2025). Heutagogy in education: Fostering self-directed learning for the 21st-century. *Journal of Career and Technical Education, 40*(1). https://doi.org/10.21061/jcte.500

OECD. (2026). OECD *digital education Outlook 2026: Exploring effective uses of generative AI in education*. OECD Publishing. https://doi.org/10.1787/062a7394-en

Sabherwal, R., & Grover, V. (2024) The societal impacts of generative Artificial Intelligence: A balanced perspective. *Journal of the Association for Information Systems, 25*(1), 13–22. https://doi.org/10.17705/1jais.00860

Shen, J. H., & Tamkin, A. (2026). *How AI impacts skill formation*. arXiv. https://doi.org/10.48550/arXiv.2601.20245

Tari, D. K., & Rosana, D. (2019). Contextual teaching and learning to develop critical thinking and practical skills. *Journal of Physics: Conference Series, 1233*, Article 012102. https://doi.org/10.1088/1742-6596/1233/1/012102

Zhang, S., Zhao, X., Zhou, T., & Kim, J. H. (2024). Do you have AI dependency? The roles of academic self-efficacy, academic stress, and performance expectations on problematic AI usage behavior. *International Journal of Educational Technology in Higher Education, 21*, Article 34. https://doi.org/10.1186/s41239-024-00467-0

Zviel-Girshin, R. (2024). The good and bad of AI tools in novice programming education. *Education Sciences, 14*(10), Article 1089. https://doi.org/10.3390/educsci14101089