

EVALUATION OF THE TUNNEL ENGINEERING COURSE LEARNING AND TEACHING WITH AI APPLICATION

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Abstract

As the powerful generative artificial intelligence (AI) is increasingly reshaping education modes, the education today is crucially intertwined with technology, such as in terms of educational content and pedagogy. It is vital to integrate AI in education to adapt to the potential of generative AI unsettling and upending in learning and teaching practice. However, in his transforming process, there is short of mature experience from practice to make the AI application increasingly effective, such as in terms of specific course learning and teaching. Here is the practice of the Tunnel Engineering course learning and teaching evaluation with the AI application under consideration. The evaluation focus on the student capacity building processes in AI-applied learning environments, with special reference to the cultivation of critical thinking. The experiences from the course learning and teaching procedures indicate that students are skillful in AI application to sample information to finish objective issues, while most of the students could not effectively manage the subjective issues, in which personal judgement and decision-making with various information are involved. When taking the advantages of AI application in this professional course learning and teaching, we should timely assess the potential misleading or temporary prosperity induced by the abundant multi-functional information that is blurring student cognition developing.

Keywords: *Evaluation, tunnel engineering course, learning and teaching, AI application.*

1. Introduction

As the powerful generative artificial intelligence (AI) is increasingly reshaping education modes, the education today is crucially intertwined with technology. Open Generative AI tools such as GPT and DeepSeek are directly or indirectly everyday companions in the tertiary learning and teaching activities. A recent global survey indicated that 86% of university students now use AI in their studies, with more than half engaging with these tools weekly (DEC, 2024). It is vital to integrate AI in education to adapt to the potential of generative AI unsettling and upending in learning and teaching practice. However, these tools are not designed with educational goals since the large language models generate responses using probabilistic language modeling, rather than through conceptual understanding or reasoning (Vendrell & Johnston, 2026). Emerging researches on the effects of the application of generative AI tools in education (e.g., Deng et al., 2024; Gerlich, 2025) indicated both beneficial and harmful outcomes, which are contingent rather than fixed (Vendrell & Johnston 2026). We need the competency collaborating with AI systems in higher education on the condition without surrendering cognitive agency. However, in his transforming process, there is short of mature experience from practice to make the AI application increasingly effective, such as in terms of specific course learning and teaching. As a course is of service to students' capacity development, the effects of AI applications in the course learning should be timely assessed to follow student-centered education principle. Here is the preliminary practice of the Tunnel Engineering course learning and teaching evaluation with the AI application under consideration.

2. Considerations

Education is essential to our society. The promoting effects of the contemporary education to the social development is increasingly significant in this digital era. One of the features of the current world is changing. A prosperous society needs competent people to cope with the various and endless information. Therefore, the college students would have the basic capacity of navigating and coping with the complex and dynamic environments. Capable personnel would be involved in various cognitive processes, including problem-solving, decision-making, and reflective thinking in the future professional life. Critical thinking,

defined as the ability to analyse, evaluate, and synthesise information to make reasoned decisions (Halpern, 2012), is one of the key natures of competent personnel and is a fundamental cognitive skill essential for academic success, professional competence, and informed citizenship (Gerlich, 2025). With the rapid advancement of AI technology, its impact on higher education is pervading in almost aspects. The effect of the AI application on learning outcomes, especially on critical thinking development should be evaluated in a course procedure. Here is the presentation on the evaluation of the Tunnel Engineering course learning and teaching with AI application, in terms of the features of capacity requirements and the effects of the AI application in critical thinking development.

2.1. Impact from AI application

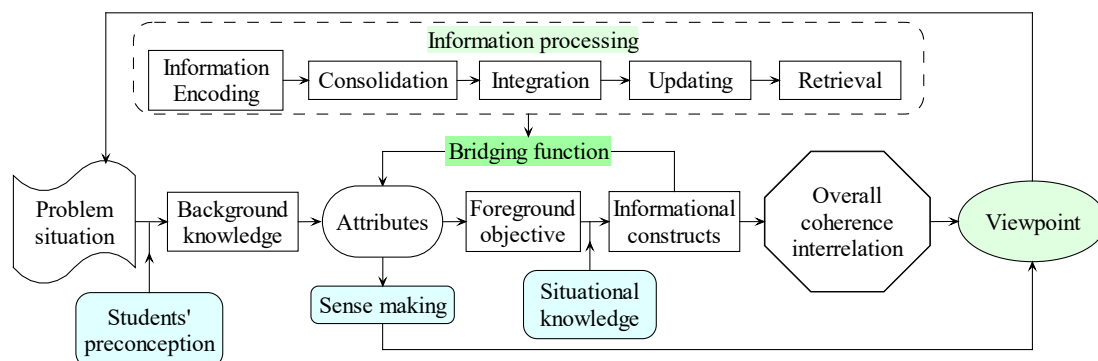
AI application is spreading to almost all aspects of traditional teaching in universities. AI tools offer undeniable benefits in terms of efficiency and accessibility (Gerlich, 2025). During course learning and teaching, AI tools would provide environmental support for self-directed learning, resource platforms for personalized learning, and precise empowerment for learners with learning difficulties. It seems AI tools would replace almost traditional knowledge education procedure. Under AI's pervasive influence, the transition of both teaching and learning models is imperative. For example, the importance of traditional knowledge learning in higher education has significantly decreased and the cultivation of students' thinking abilities has become increasingly important. As information is readily available, one of the characteristics of the AI era is the increasing uncertainty. In this context, traditional thinking aimed at pursuing a single deterministic answer will no longer be applicable. In contrast, the cultivation of systems thinking, engineering thinking and creative thinking has become more important. Critical thinking is increasingly vital to cope with the dynamic situations, as considering the negative effects of AI application on critical thinking, such as cognitive offloading, diminishing users' engagement in deep, reflective thinking processes (Gerlich, 2025; Vendrell & Johnston 2026).

2.2. Features of capacity requirements

In simplicity, Tunnel Engineering is a subject dealing with the planning, design, construction, operation and management of tunnels and underground structures. The numbers and complexity of tunnels and underground structures are increasing with time. The information pertaining to the Tunnel Engineering is accordingly accumulating. The features of the professional capacity requirements in the field of Tunnel Engineering would be under consideration in the course learning and teaching.

2.2.1. Features of the course. As mentioned above, the course Tunnel Engineering would include the contents of the planning, design, construction, operation and management of tunnels and underground structures. We need understanding of what data, information, knowledge, and wisdom mean to us and how their interrelating enables us to define and move along a knowledge building pathways (Kaipa, 2000). Date and information could indicate us hints to do things right, while knowledge means knowing how and why to do the right things. Students would transform from information accepting into an information assimilating in terms of knowledge building and capacity developing. It is a procedure of making the information separated to be assembled into a student's knowledge system, as shown in Figure 1. The related information is too plentiful to be fully considered in the course learning and teaching practice. The course activity would focus on the basic information and knowledge, pertaining to the essential concepts, principles, theories, technologies in the field of tunnel and underground structures. Considering the features of the course contents in terms of information and knowledge, the course procedure should be performed with the application of systems thinking (Ma, 2022).

Figure 1. Information processing, sense making and knowledge building procedure (modified from Labour, 2014).



2.2.2. Capacity requirements. Of the student capacity development in a course learning, it would include learning ability and professional competence. Both would strongly depend on the level of critical thinking. In practice, a qualified engineer would have professional judgement to cope with the project increasing complex tendency. Therefore, it is important to cultivate the learning capacity, which includes sampling information, knowledge building and sense making. During intrapersonal knowledge building or creation, there needs personal ability of verbal formulations to capture the essence of various aspects of unformulated experience, such as in terms of a step towards theorizing key aspects of an informational process (Figure 1). This process is situational interactions between a learner and the information in his or her sense-making process and is strengthened by the bridging function of informational constructs and bringing together attributes that deduce from learner's sense-making process. On the contrary, without reflection, such as no interaction between the students' set objective and situational knowledge, there is no viewpoint about the problem situation. The loosely built knowledge will eventually become meaningless or dissipated (Labour, 2014). The researches on memory storage and management mechanisms indicate that effective memory framework would consist of memory extraction, updating, retrieval, and utilization, enabling persistent experience regulation and long-range reasoning and evolve from stateless responders into continuous learners capable of long-range reasoning (Liang, Li, Li et al., 2025). Otherwise, the process would be cognitive offloading and unfavorable to critical thinking skills developing (Gerlich, 2025) when individuals delegate cognitive tasks to external aids, reducing their engagement in deep, reflective thinking (Carr, 2010; Sparrow, Liu & Wegner, 2011).

2.3. Evaluation points and parameters

As the learning process would be negatively influenced by improper AI tool usage such as due to increased cognitive offloading (Gerlich, 2025), the practice of a course plan implementation should be evaluated with proper measures (Vendrell & Johnston, 2026).

2.3.1. Evaluation points. To evaluate the influence of AI tool application on student's capability development, the evaluation would be executed in a dynamic mode. To meet the various social requirements, the course process will be with college characteristics, such as in terms of knowledge-level, personal abilities and objectives. There are well-accepted parameters of personal capacity in the field of social evaluation, such as the Bloom's taxonomy (Anderson & Krathwohl, 2001), with creative thinking in the top-level or higher-order. In the cultivation of critical thinking in higher education, cognitive ability development, metacognitive engagement, epistemic norms and responsibilities are of distinct challenges, since improper use AI tools can attenuate critical thinking, such as due to cognitive offloading, metacognitive disengagement and epistemic narrowing (Vendrell & Johnston, 2026).

2.3.2. Parameters. With the focus to evaluate the student intellectual processes in AI-applied learning environments, the six parameters (Table 1) proposed by Vendrell & Johnston (2026) are under consideration in the course learning and teaching procedure. These parameters are indeed interrelated processes, with the indication of learner's thinking and critical engagement, and could underpin higher-order thinking and critical engagement as learners navigate the epistemic affordances (Vendrell & Johnston, 2026). The key focus of these parameters is to investigate how critical thinking is underlined in the course learning process.

Table 1. Evaluation parameters, indications and practical cases in the course implementation.

Parameters	Capacity indications	Practical cases in evaluation
Conceptual interpretation	Understanding, analyzing	Quiz, open-book test
Inferential reasoning	Analyzing, evaluating, creating	Homework, course project, open-book test
Evaluative judgement	Evaluating, decision-making	Homework, course project, open-book test
Metacognitive regulation	Metacognitive monitoring and regulation	Homework, course project, open-book test
Intellectual curiosity	Inquisitiveness, flexible thinking	Homework, course project, open-book test
Epistemic integrity	Truth-seeking, ethical reasoning	Homework, course project

3. Practice and results

At the start, we perform an anonymous investigation on the situation of AI tools application in the course study. Two semesters' results are similar. Nearly all of the students are using AI tools as a key

referring measure in fulfilling academic assignments, such as homework, project and essay writing, though there is deference in tools option and the degree of dependence. They prefer AI tools in reference information sampling to the traditional browsing printed literatures. Therefore, we need to consider the course plan with AI application. During the course plan implementation, lecturing, extemporaneous discussions and minor quiz are the main performance modes. The evaluation on the influence of the AI tools application on the students learning and capacity development mainly focus on the students' performance in the issues outside the classroom, including homework, course project, review report on specified topic. Open-book test and quiz within limited time are also used in the course process.

3.1. Evaluation in practice

As professional education is essential foundation to our social development. In a broader sense, professional course is to promote student thinking, being, and acting in the practical field. Therefore, professional education would include the capacity for self-understanding, social critique, and principled action, and can be evaluated with the parameter's conceptual interpretation, inferential reasoning, evaluative judgement, metacognitive regulation, intellectual curiosity and epistemic integrity (Table 1). The evaluation points with the specified measures for the evaluation parameters are presented in the Table 2, to assess how critical thinking can be cultivated in AI-mediated learning environments, including dispositions at risk when AI tools are used uncritically (Vendrell & Johnston, 2026).

The evaluation is performed with both formative and summative assessment measures, including homework, essay writing, course project, open-book test, midterm and final exams. Some of the assessment topics are specifically designed with AI application under considerations. Students are positively encouraged to indicate their AI tools usage levels and modes. In the formative assessments, the skills of the AI tools usage are also evaluation factor. The students submitting are valued with the key points of the evaluation measures as reference indicators for the parameters, respectively.

Table 2. Key points of the evaluation measures for the evaluation parameters.

Parameters	Key points of the evaluation measures
Conceptual interpretation	The ability to construct meaning by selecting, organising, and integrating information; to clarify concepts, discern relationships, and translate complex ideas into one's own understanding; to distinguish core ideas from peripheral details, reconcile competing views, and connect new input to prior knowledge
Inferential reasoning	The ability to generate reasoned conclusions from evidence; to identify assumptions, discern logical relationships, and predict implications; to construct arguments, identify causal links, test hypotheses across contexts, reason and make decision under uncertainty
Evaluative judgement	The ability to assess the credibility, coherence, and evidentiary basis of information and arguments; to compare competing interpretations and determine whether conclusions follow logically from premises; to judge the quality and relevance of sources
Metacognitive regulation	The ability to monitor, evaluate, and control one's cognitive processes during learning and reasoning; to assess task demands, recognise cognitive biases, and modify their approach with errors or gaps being detected
Intellectual curiosity	The motivation to explore ideas and questions, and pursue knowledge beyond requirements
Epistemic integrity	The traits of truth-seeking and fair-mindedness; the intellectual honesty with critical reflexivity

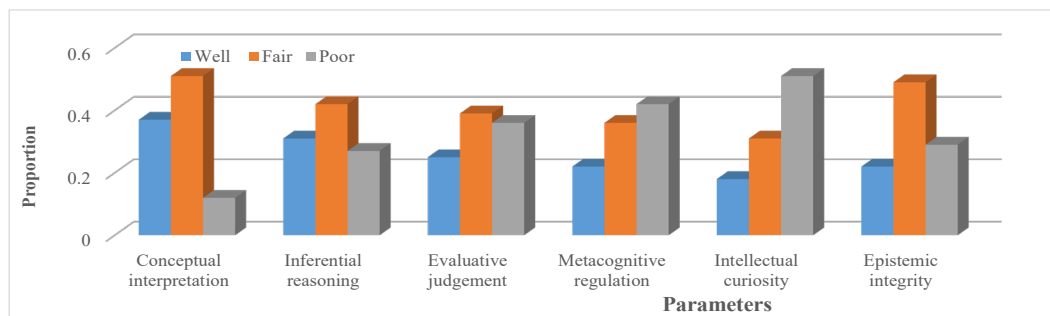
3.2. Results of the evaluations

Based on the two-semester Tunnel Engineering course practice, the preliminary evaluation results on the effect of AI tools application in the learning and teaching are the followings.

Students are generally skillful to learn how to use an AI tool and to manage information available to fulfill a standardized task, such as answering a question without high logical or reasoning thinking being involved. More than half of the students can offer a polished essay writing on a specified topic, at least deferring to surface-level coherence. However, students' performance is not same as intuitive judgement when they are accomplishing a relatively complex task with the critical thinking parameters (Table 2) being involved. As the students' learning performance being evaluated as well, fair and poor with the compliance to the evaluation measures, respectively, the statistical evaluation results are shown in Figure 2. In general, the well-performance ratio varies from 0.18 to 0.37, which is similar to the excellent ratio of student course achievements. In historical comparison, the students' performances in AI-mediated environments are not superior to that of their antecedent peers, such as in terms of total score, results of summative test and course project, where critical thinking is underlined in assessments. The preliminary results imply that the AI-mediated environments, with plentiful information readily available, efficient and convenient tools, do not directly improve student capacity-building effectiveness, especially with critical thinking under

consideration. Timely assessment of the learning and teaching procedure is indispensable in underpinning the importance of student's personal thinking under this plentiful and challenging education environment.

Figure 2. Evaluation results of student learning performance with critical thinking under consideration.



4. Conclusions

Based on the preliminary practice of the course learning and teaching evaluation with the AI application under consideration, conclusions are as followings. (1) Students are skillful to use an AI tool to sample in literatures and to fulfill a standardized task. (2) AI-mediated environments do not directly improve student capacity-building effectiveness, especially with critical thinking under consideration.

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