Urgent questions for engineering education in the age of GenAI: knowledge, teaching, & assessment

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SIMSG ISSMGE
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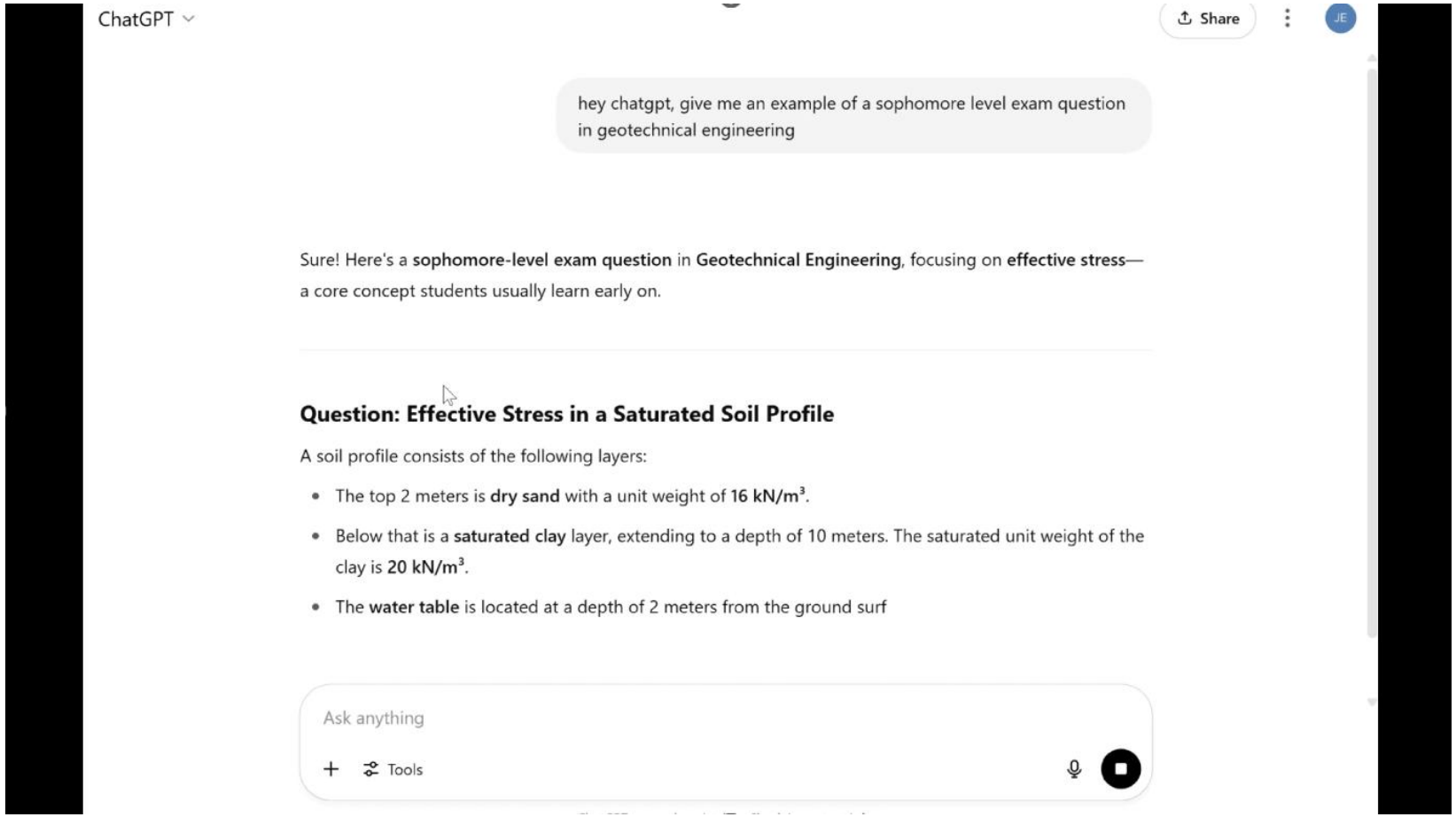
ÉCOLE NATIONALE SUPÉRIEURE GÉOLOGIE NANCY
cfms COMITÉ FRANÇAIS DE MÉCANIQUE DES SOLS ET DE GÉOTECHNIQUE
VIRGINIA TECH

A “checking in” exercise

[omitted] clip showing video screen shot of engagement with ChatGPT – show a typical geotechnical eng exam and then show a worked solution – screen shot here just showing the first prompt:



Tick the statements you agree with:

https://www.law.com/legaltechnews/2024/03/28/education-in-the-age-of-gen-ai-negotiating-skills-are-alive-and-well/

The age of GenAI is with us…

https://sites.campbell.edu/academictechnology/2025/03/06/ai-in-higher-education-a-summary-of-recent-surveys-of-students-and-faculty/
https://www.nytimes.com/2025/06/07/technology/chatgpt-openai-colleges.html
Johri, A., Schleiss, J., & Ranade, N. (2025). Lessons for GenAI Literacy From a Field Study of Human-GenAI Augmentation in the Workplace. *arXiv preprint arXiv:2502.00567*.

“It is easier for students to incorporate GenAI use into their ‘learning’ practices, compared to faculty, and therefore the adoption by them is much higher. Reflective use is not absent, but it is not the norm.
Chat GPT succeeded because it leveraged a mental model young people were familiar with – conversational exchange of information.”

(Johri, 2025)

Johri, A. (2025) Designing the Future of Engineering Education through (Generative) Artificial Intelligence, Mudd Design Workshop, https://drive.google.com/file/d/1QtyQj-ndqEOxjbl1NspMLc0b7oJkX48q/view

This talk

- Firstly: What it is not!
- Tech disruptions force us to raise the really important questions on what matters in engineering education.
- We can’t find the answers to these questions from within the technology itself.
- These are fundamental **educational** questions.

Hodges, C. B., & Kirschner, P. A. (2024). Innovation of instructional design and assessment in the age of generative artificial intelligence. *TechTrends*, *68*(1), 195-199.

What are the key questions for us as engineering educators and researchers?

1. What do students need to know?
2. What is the role of the teacher?
3. How can we assess that learning has happened?

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1. The knowledge question
2. The teaching question
3. The assessment question

1. The knowledge question

The education of engineers

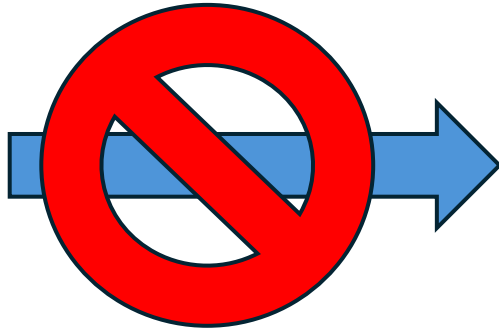
Findings from our study which asked engineers, 10 years into their careers:
“What did an engineering degree give you?”

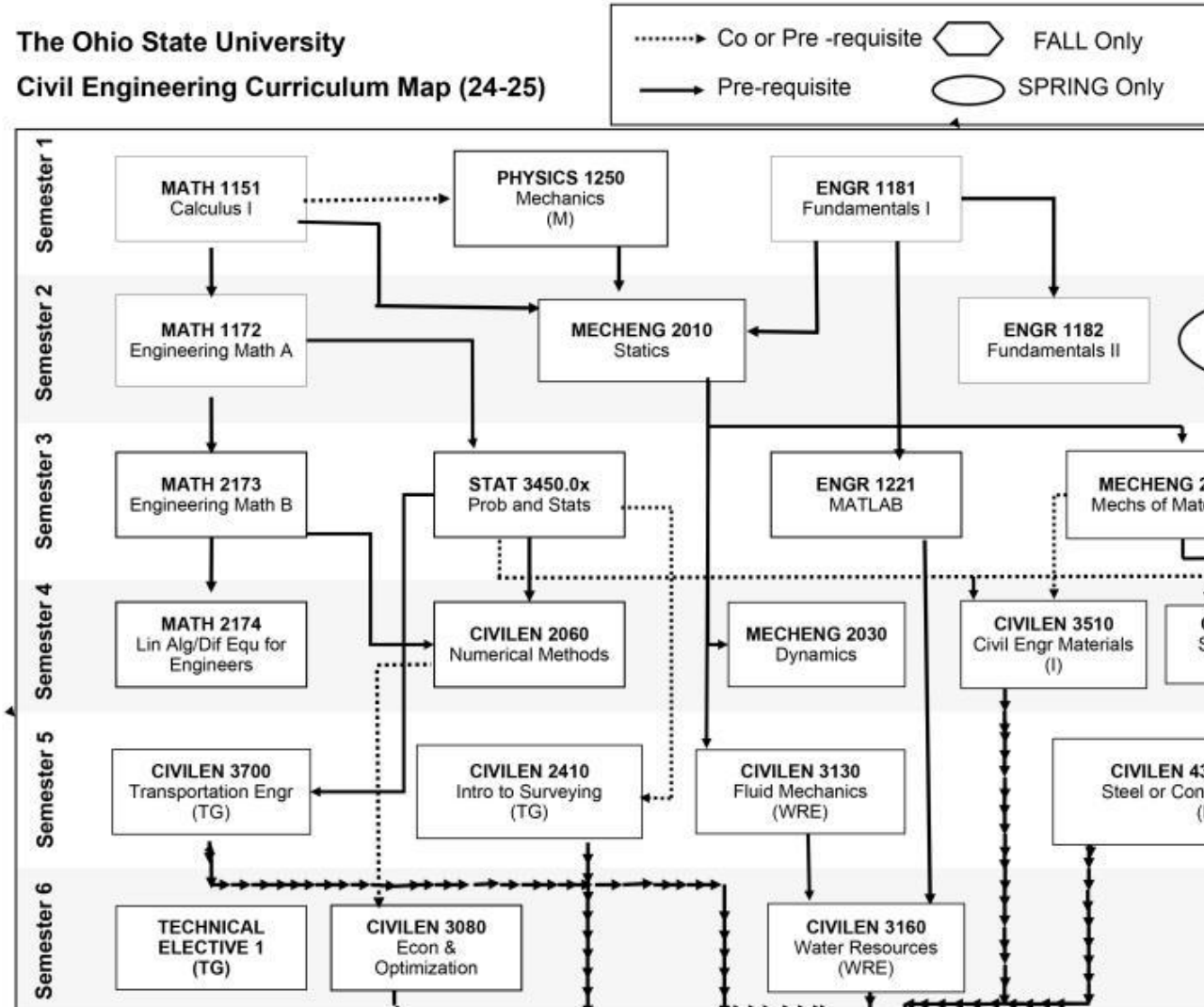
- Confidence to tackle problems
- Engineering approach to problem solving
- Working independently
- Ability to learn new knowledge

Case, J. M., & Marshall, D. (2016). Bringing together knowledge and capabilities: A case study of engineering graduates. *Higher Education, 71*(6), 819–833. doi:10.1007/s10734-015-9932-4

You can’t reverse engineer from workplace practice back to formal curriculum

https://www.citizen.co.za/roodepoort-record/news-headlines/2015/02/10/sasol-boosts-number-of-female-chemical-engineers/





Designing an engineering curriculum based on excel skills?

https://www.meyerfire.com/blog/why-engineers-should-love-excel

You can’t avoid knowledge

1. Being able to access information is not the same as being able to understand that information
2. Understanding is needed in order to be able to do anything useful with information – crucial for professionals
3. You can’t teach skills without a knowledge base on which to develop those skills. Limited value in a generic skills course.

Surma, T., Vanhees, C., Wils, M., Nijlunsing, J., Crato, N., Hattie, J., ... & Kirschner, P. A. (2025). Knowledge and the Curriculum. In *Developing Curriculum for Deep Thinking: The Knowledge Revival* (pp. 37-73). Cham: Springer Nature Switzerland.

Start with identifying the threshold concepts in your discipline

"Particular concepts in a given discipline which cannot easily be assimilated or accommodated within one's existing meaning frame. …
To accommodate such new and troubling knowledge will require not only a difficult reconceptualization, but a reformulation of one's meaning frame."

Land, R., Meyer, J. H., & Flanagan, M. T. (Eds.). (2016). *Threshold concepts in practice*. Springer., p. xi

A threshold concept in geotechnical engineering: effective stress

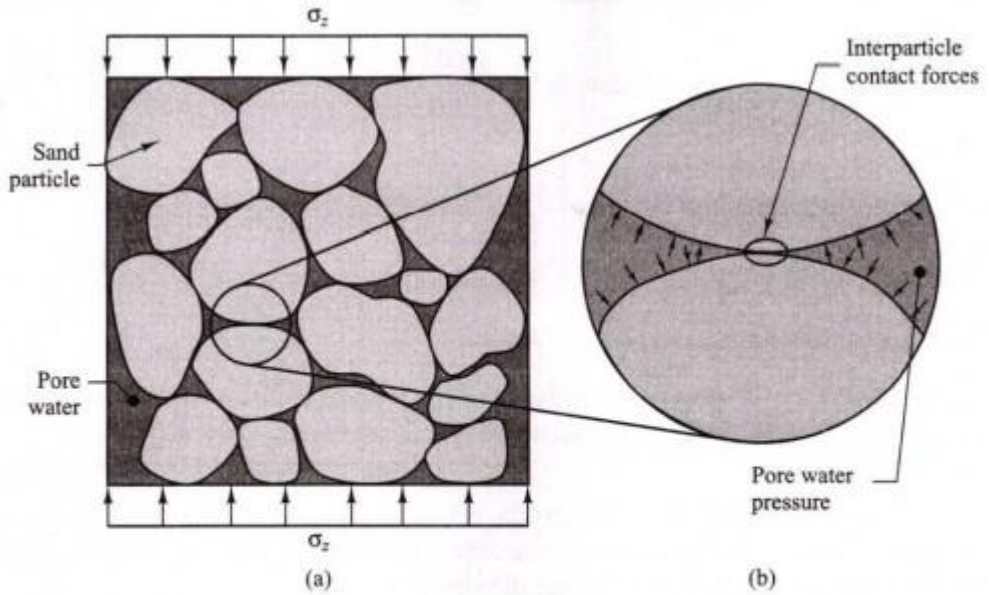


FIGURE 9.21 Illustration of the division of total stress in to effective stress and pore water pressure. Panel (a) shows a saturated soil element carrying a total vertical stress of σ_z. This total stress is carried by both the pore water pressure, u, and the effective stress, σ'_z. Panel (b) is a close-up of an interparticle contact. The effective stress is the portion carried by the interparticle contact forces.

https://www.alpsconsult.net/post/effective-stresses-vs-total-stresses

Pantazidou, M. (2020). Teaching the Big Ideas of the Disciplines: Online Educational Material Accessible to Everyone for Soil Mechanics' Effective Stress, Proceedings of the International Conference on Geotechnical Engineering Education 2020 (GEE2020), Pantazidou, Calvello & Pinho Lopes (eds.), obtained from https://www.issmge.org/publications/online-library.

Testing for conceptual knowledge

GEE 2025 - Geotechnical Engineering Education 2025
International Conference "Charting the path toward the future"
organized by TC306 - ISSMGE

Nancy, France
2-4 July 2025

Developing concept inventories for Geotechnical Engineering

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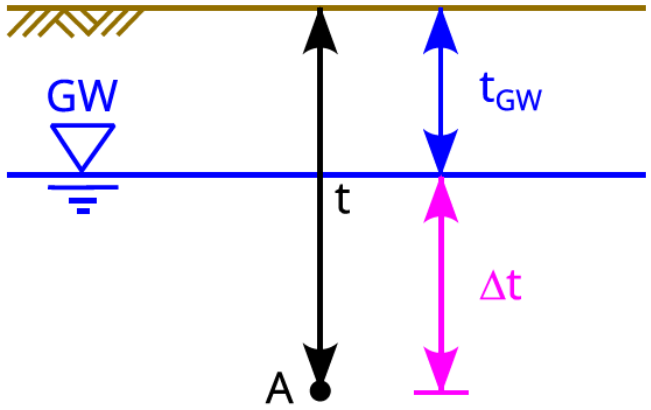
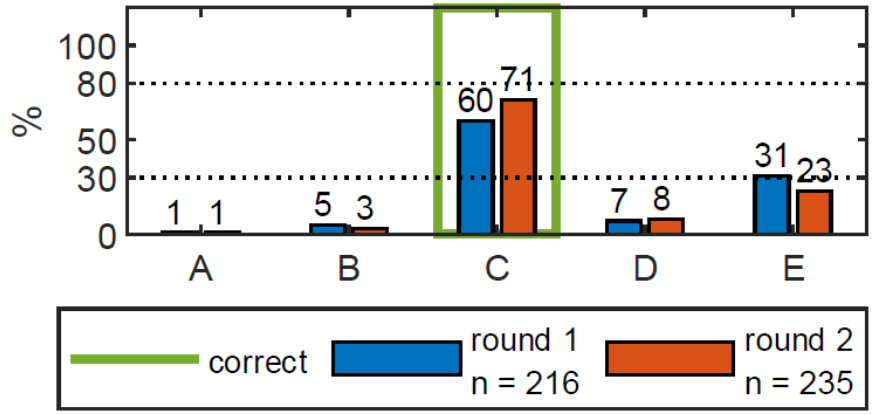
Question 2.2 (Effective vertical stress)

The effective vertical stress at point A is calculated by:

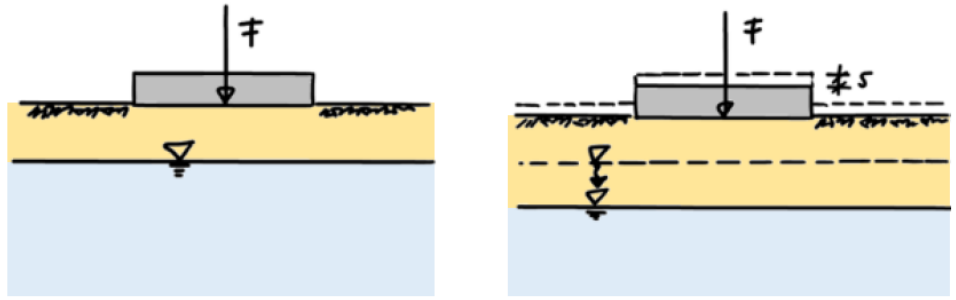


A) $\gamma \cdot t$
B) $\gamma' \cdot t$
C) $\gamma \cdot t_{GW} + \gamma' \cdot \Delta t$
D) $\gamma' \cdot t_{GW} + \gamma \cdot \Delta t$
E) $\gamma \cdot t_{GW} + \gamma_w \cdot \Delta t$



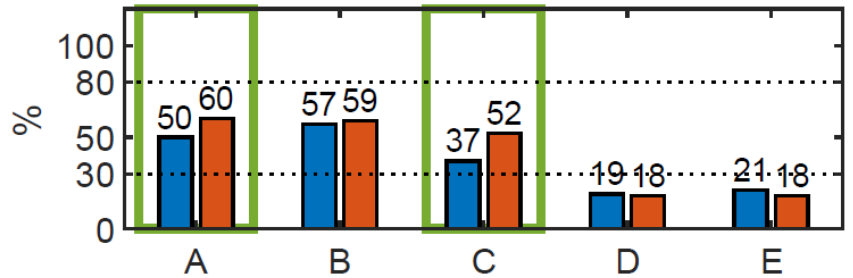
Question 3.1 (Groundwater settlement)

Why does settlement occur due to groundwater lowering?



before after

A) Because the wet unit weight γ is greater than the buoyant unit weight γ'.
B) Because groundwater lowering creates cavities in the subsoil.
C) Because of increased effective stresses in the soil.
D) Because of increased total stresses in the soil.
E) Because the wet unit weight γ is smaller than the buoyant unit weight γ'.



2. The teaching question

The challenge of teaching for conceptual acquisition is not new

https://www.learner.org/series/a-private-universe /

The real challenge: shifting students' approaches to learning

Surface	Procedural	Deep
		Thabo
		John
	Passed the course	Eddy
		Mike
	Lindiwe	
	Geoff	
	Thembi	
	Andrew	
Nomsa	Nomsa	
Maria		
Shakira		

→ : metacognitive development = shift in approach to learning

Case, J. M., & Fraser, D. M. (2002). The challenges of promoting and assessing for conceptual understanding in chemical engineering. *Chemical Engineering Education*, *36*(1), 42-53.
Case, J., & Gunstone, R. (2002). Metacognitive development as a shift in approach to learning: an in-depth study. *Studies in Higher Education*, *27*(4), 459-470.

Q: What does teaching have over an AI agent?

A: A human relation

Are we leveraging this?

Flenady, G., & Sparrow, R. (2025). Cut the bullshit: why GenAI systems are neither collaborators nor tutors. *Teaching in Higher Education*, 1–10.

The lecture is dead. Long live the lecture!

Our recent research on what students value in engineering lectures:

1. Explanations - of difficult concepts
2. Interaction – being able to ask questions
3. Resources – support for private studying

The ones I like is when they do it on the board as they're going through the lectures….It's generally slower because they have to keep up with themselves. They can't just flip through slides. [2nd year chemical engineering student]

Case, J. M., Agrawal, A., Abdalla, A., Pitterson, N., & McArthur, J. (2024). Students' experiences of the value of lectures for their learning: a close-up comparative study across four institutions. *Teaching in Higher Education*, *29*(6), 1638-1656.

3. The assessment question

New answers to old questions?

1. Students being able to bypass learning in order to pass their courses is NOT NEW.
2. But – present AI tools supercharge these possibilities
3. Likely future developments:
    1. More in-person assessments without internet access
    2. More oral assessments
4. Formative ⟹ summative assessments

Nikolic, S., Suesse, T. F., Grundy, S., Haque, R., Lyden, S., Lal, S., ... & Belkina, M. (2025). Assessment integrity and validity in the teaching laboratory: adapting to GenAI by developing an understanding of the verifiable learning objectives behind laboratory assessment selection. *European Journal of Engineering Education*, 1-28.

Why it all matters

“Students who haven’t developed their own knowledge foundations will be increasingly marginalised in a world that paradoxically values human expertise more, not less, as AI advances.”

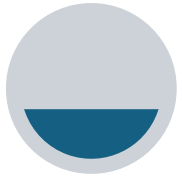
(McKenna & Tshuma, 2025)

https://theconversation.com/ai-can-be-a-danger-to-students-3-things-universities-must-do-255652

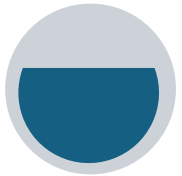
In conclusion:

What scholarly minded academics can do

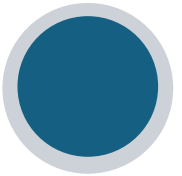
Options for scholarly engagement depending on your academic role and time at hand:



Scholarly teaching



Scholarship Of Teaching and Learning



Engineering Education Research

Hutchings, P., & Shulman, L. S. (1999). The scholarship of teaching: New elaborations, new developments. *Change: The magazine of higher learning*, *31*(5), 10-15.

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