

# Using AI to Make Definitions Personal

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## Abstract

This article presents a classroom activity using ChatGPT to support K-12 students in refining mathematical definitions. Definitions are central to mathematical understanding, yet students often struggle with the formal language surrounding them. To address this, the authors designed a prompt-structured task where students iteratively refined self-generated definitions through conversational feedback with ChatGPT. Two strategies, questioning and feedback, guided students to reflect on and revise their definitions across multiple rounds. Findings suggest that interacting with the LLM helped students articulate and improve their concept images, encouraged precise mathematical thinking, and provided timely, low-stakes feedback. Students responded variably to the task structure, revealing both benefits and limitations, such as technical access issues and prompt fatigue. Despite challenges, this pilot trial demonstrates that LLMs can serve as effective tools for promoting conceptual understanding and critical reasoning in mathematics. The authors advocate for continued exploration of AI tools that position students as active participants in their own learning.

**Keywords:** Mathematical Definitions, Large Language Models (LLMs), Artificial Intelligence in Education, Concept Image and Concept Definition, Formative Feedback, Pre-service Teacher Education, Critical Reasoning

## 1 Introduction

As unassuming definitions are, they play a key role in mathematicians' professional work (Zaslavsky & Shir, 2005). In K-12 mathematics classrooms, definitions are foundational for key mathematical practices such as constructing viable arguments, critiquing the reasoning of others, and attending to precision (National Governors Association Center for Best Practices and the Council of Chief State School Officers (CCSSO), 2010). In geometry content standards, students' use of definitions is widely called for, although frequently students will struggle because the language that surrounds definitions can seem arbitrary, cumbersome, or needlessly complicated. (Tabach & Nachlieli, 2015; Waters & Waters, 2023).

How can teachers help students build expertise in working with definitions? We believe providing students with opportunities to create and refine their own mathematical definitions is a useful technique teachers can use to facilitate student learning (Vinner, 2002). Feedback is crucial in this process, and as Shute (2008) notes, care must be taken with how it is given. She claims critical or controlling feedback can have adverse effects, thwarting students in their attempts to improve, and poorly timed feedback may be ineffective in influencing students' encoding of information.

The goal is to avoid these setbacks, but there are many pedagogical tasks teachers must attend during a lesson, and they are restricted in how much personalized feedback they can give to each student. Most classrooms will have a teacher-to-student ratio of less than one. Moreover, even if feedback is

personalized and non-constricting, there is no guarantee that students will fully understand a concept from a single instance of feedback. Again, although the timing of feedback is not down to science, some researchers believe not giving students feedback in a timely manner may incidentally give them time to encode their beliefs into their memory before they can be addressed or refined (Shute, 2008). Students can and should take autonomy in how they work, but they need guidance in the form of repeated feedback.

This is where large language models (LLMs), such as ChatGPT, can reduce the workload of teachers. LLMs are artificial intelligence models which individuals can interact with using natural language. Teachers can leverage LLMs to provide real-time feedback to their students by having the language model serve as an immediate sounding board. Students will work with their own ideas and reform those ideas as they respond to the LLM's feedback. Previous research has explored use of LLMs as providers of feedback with respect to mathematical accuracy (Redding et al., 2025). In this article, we expand this research into concept building, presenting a prompt-structured task to help teachers navigate this problem of practice. The prompt structure guides students to use ChatGPT and engage in a conversation that helps them create and refine their own mathematical definitions. Rather than using the LLM as a dispenser of definition, students work with it as a collaborator, helping them as they home in on the conciseness and clarity of their mathematical thinking.

In this article, we explored the interactions and outcomes resulting from our students engaging in a structured-prompt task that our students engaged through ChatGPT. Two classes participated in this activity. The task, designed to give students formative feedback, ensured that the students' engagement was aligned with their learning goals. It not only facilitated connections between their personal understanding of mathematics with more generally accepted notions but also acted as a space for students to receive criticism for their thoughts before having to interact with their peers or instructors. In the sections that follow, we illustrate ways in which the task promoted students' conceptual understanding, as well as challenges and perceptions that arose from engaging in the task.

## 2 Description of Innovation

ChatGPT rolled out in November 2022, and despite its increasing commonality in the public sphere, it has had limited time to find its footing in the classroom. Furthermore, Edwards, Yang, and Lopez-Gonzalez (2024) noted that LLMs in general have been framed as tools used for academic dishonesty. This is not an unprecedented belief. UNESCO (2023) claims that LLMs can do more for a student beyond typing out essays for them. Furthermore, Anders (2023) also asked the question whether LLM usage should be considered plagiarism. To counter this narrative, Edwards and colleagues (2023) attempted to reframe the narrative to present ChatGPT as an educational tool that can be used to further student reasoning. They did so through the use of AI agents, a pre-seeded prompt which forces LLMs to remain in line with their learning goals. While this system could have been used for the task presented in this article, the current authors decided to omit its use in favor of encouraging students to begin to interact more candidly with LLMs, in a way they may naturally do when working with LLMs outside the classroom and as encouragement to make them life-long learners.

Vinner (2002) helped develop the ideas of concept image (the mental representations formed through experience) and concept definition (precise statements that specify the necessary and sufficient conditions for something to be an instance of a particular concept), and used these ideas as a framework when focusing on the challenges students face when learning formal mathematical definitions. He argued that students often rely on their intuitive concept images rather than the precise concept definitions provided in formal instruction. Vinner (2002) also emphasized that simply memorizing definitions does not guarantee understanding. He suggested educators should recognize the distinction

between a student's concept image and the formal concept definition and address potential conflicts between the two. In doing so, teachers could help students develop deeper and more accurate understandings of mathematical concepts. The prompt structure presented will begin with students presenting their own definition of certain mathematical terms, so that they can verbalize their concept images and work on them directly.

As they introduce their definitions to ChatGPT, students will also explicitly tell the LLM about their academic background (the participants in this proof-of-concept were pre-service k-12 teachers) and ask for feedback following one of two strategies. The first strategy is the questioning strategy, where students ask ChatGPT to respond with one question to help them improve their definition. The second strategy is the feedback strategy, where students ask ChatGPT for one thing it agrees with and one thing it disagrees with. After receiving feedback, the students take up the feedback and reconstruct their definitions to address any feedback they found prevalent. This action is repeated three times, each time with the student asking for feedback and reintegrating it into their definition. On the third reattempt, the student asked for a final evaluation, and then asked the LLM to list criteria that it used when evaluating the students' definition.

*Note:* Depending on the student's background, the initial statement of what the student is studying (e.g., grade level or content area) may be adjusted.

**Table 1.** *Prompt-Based Task Structure*

Step	LLM Questioning Strategy	LLM Feedback Strategy
1	I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: _____. Ask me ONE question to help me improve my definition.	I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: _____. Tell me one thing you agree with and one thing you disagree with. Do not give me your definition of quadrilateral.
2	Take up one thing from the LLM feedback and say: Let me try again. I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: _____. Ask me ONE question to help me improve my definition.	Take up one thing from the LLM feedback and say: Let me try again. I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: _____. Tell me one thing you agree with and one thing you disagree with. Do not give me your definition of quadrilateral.
3	Repeat Step 2	Repeat Step 2
4	Take up one thing from the LLM feedback and say: Here's my final definition. I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: _____. What are your overall thoughts on my definition? Do not give me your definition of quadrilateral. What criteria are you using when you provide your thoughts about my definition?	Take up one thing from the LLM feedback and say: Here's my final definition. I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: _____. What are your overall thoughts on my definition? Do not give me your definition of quadrilateral. What criteria are you using when you provide your thoughts about my definition?

*Note:* Depending on the student's background, the initial statement of what the student is studying (e.g., grade level or content area) may be adjusted.

### 3 Implementation

Two different classrooms completed the task. The first (Class A) was composed of fifteen pre-service elementary school teachers who engaged with the prompt structure twice. The first time, half of the classroom was asked to use the questioning strategy, while the other half was asked to use the feedback strategy when defining first a quadrilateral. The second time, they swapped strategies and defined a term of their choice. After this class completed the activity for the first time, they were also asked to submit a reflection on their experience with the task. Following each of their times engaging with the task, the students were asked to send the authors links to the conversations they had with ChatGPT. For students that struggled to send links with their devices, they were asked to email screenshots of their conversations to the authors. Both the conversations shared by link and the conversations screenshotted were transcribed and analyzed for themes. The second classroom (Class B) was composed of four pre-service high school teachers who were asked to use the feedback strategy to form and refine their definition for a function. These students emailed the copied text of their interactions with ChatGPT to the authors. These conversations were then examined by the authors to determine recurring themes.

#### 3.1 Notable Student Conversations from Classroom A

The students in Class A were initially asked to define a quadrilateral. Each student was then assigned either the questioning strategy or the feedback strategy. Students routinely defined a quadrilateral as a shape with four sides. ChatGPT almost always led by asking, or making note of, if the sides had to be straight. This was an indication to the instructor of the class that their explanation had not been explicit about this part of the definition with their students. Some students also added in their initial definitions of quadrilateral that the interior angles added up to  $360^\circ$ . In these cases, the LLM pushed for more properties of the quadrilaterals, without asking if this property was necessary for the definition.

Despite consistent similarities in how the class engaged in the task, there were incidents that illuminated the variety of ways students could engage with the task. The following are three such interactions.

##### Student Conversation 1.3.1

When students chose their own terms to define, one student chose the word “area”, then used the word in their definition. Although an instructor may assume students would know definitions should not be self-referential, this is not a skill that is explicitly taught. As the student tried to refine their definition of area, the AI would tell her not to use the word in the definition, but the student would refine the definition but then struggle to define “area” without using the word:

**Student:** I’m a pre-service elementary teacher. Here is my definition of area: the amount of area that is covered inside a shape. Tell me one thing you agree with and one thing you disagree with. Do not give me your definition of area.

**ChatGPT:** Great start! Here’s my feedback:

One thing I agree with: I like that you emphasized the idea of coverage inside a shape—that captures the essential idea that area relates to the space within a shape’s boundaries.

One thing I disagree with: You said “the amount of area,” which is a bit circular—it uses the word “area” to define area. That could confuse someone who’s new to the concept. Instead, you might consider using different language to describe what is being measured without repeating the term itself. You’re definitely on the right track! Want help refining it further?

....

**Student:** Let me try again. I'm a pre-service elementary teacher. Here is my definition of area: the amount of surface area covered inside a shape. Tell me one thing you agree with and one thing you disagree with. Do not give me your definition of area.

While there was an iteration where the student above did not use "area" in their definition, they iteration after that one when defining it as "surface area". The single correction from the LLM was not enough to make the student realize the word being defined cannot appear in the definition.

### Student Conversation 1.3.2

Another student who was using the questioning strategy began exploiting the LLM by responding "no" to the questions they were asked. After replying "no", the AI replied with a possible alternate definition which the student began to use as their new refinement:

**Student:** I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: a quadrilateral is a 4 sided figure. Ask me ONE question to help me improve my definition.

**ChatGPT:** Does your definition account for the fact that a quadrilateral is a closed figure made of straight lines?

**Student:** no

**ChatGPT:** How about refining your definition to: "A quadrilateral is a closed figure with four straight sides"? This ensures clarity and precision!

**Student:** no.

**ChatGPT:** How about refining your definition to: "A quadrilateral is a closed figure with four straight sides"? This ensures clarity and precision!

**Student:** Let me try again. I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: A quadrilateral is a closed figure with four straight sides. Ask me ONE question to help me improve my definition.

This is an example of a student breaking the structure of the task and then using the way the LLM responds to reduce the student's cognitive load. This defeats the purpose of the task, however, as the student is no longer practicing the skill of self-refinement. The following student conversations show another way the structure of the task can be broken, but without reducing the task's cognitive demand.

### Student Conversation 1.3.3

This student broke from the prompt structure and began to simply respond with their updated definition to the LLM, without giving any context. The LLM still continued to give feedback, and the student continued to integrate the feedback in their definition. This showed the possibility of simplifying the task structure for more natural interactions in future implementations of the task:

**Student:** I'm a pre-service elementary school teacher. Here is my definition of quadrilateral: a shape that has four sides. Ask me ONE question to help me improve my definition.

**ChatGPT:** Does your definition account for the fact that a quadrilateral must also have four angles and be a closed shape?

**Student:** A quadrilateral is a closed shape that has four sides and four angles.

**ChatGPT:** Great! Now, consider this: Does your definition account for different types of quadrilaterals, such as squares and rectangles, and how they relate to each other?

**Student:** A quadrilateral is a closed shape that has four sides and angles and can be a variety of types, but they can all be one another.

**ChatGPT:** You're on the right track! However, the phrase "they can all be one another" may cause confusion since not all quadrilaterals share the same properties. For example, while a square is always a rectangle, a rectangle is not always a square. Here's a revised question to refine your definition further: How can you clarify that quadrilaterals come in different types, but not all quadrilaterals share the same properties?

### 3.2 Student Conversation from Classroom B

The four students in classroom B exclusively used the feedback strategy to define "functions." The students in this classroom were more methodical, directly addressing the feedback with every iteration, and sticking to the prompt structure directly. For these students, most of their refinement revolved around the specificity of domains and codomains of the function. ChatGPT made recommendations to one student for their definition in how they would explain functions to highschoolers. This student had a technical definition of "function", and the following interaction occurred:

**Student:** I'm a preservice high school math teacher. Here is my definition of a function: A relationship between input and outputs that maps a specific input to at most one output. Tell me 1 thing you agree with and 1 thing you disagree with. Do not just give me your definition of function.

**ChatGPT:** Agree: I agree that your definition correctly emphasizes that a function must assign at most one output to each input. This is the core idea behind what makes a relationship a function—it must be well-defined, meaning each input corresponds to one (or no) output, but never multiple. Disagree: I disagree with the phrase "at most one output." While technically true in a loose sense, this wording may mislead students into thinking it's okay for an input to have no output at all. In standard high school math contexts (and in most definitions), a function assigns exactly one output to each input in its domain. The idea that a function might not produce an output for an input typically arises only in more advanced or partial function contexts.

**Student:** I'm a preservice high school math teacher. Here is my definition of a function: A relationship between input and outputs that maps exactly one output to each output. Tell me 1 thing you agree with and 1 thing you disagree with. Do not just give me your definition of function.

**ChatGPT:** Agree: I agree with your emphasis on the idea of exactly one output, which helps reinforce the importance of functions being predictable and consistent—each input must lead to a single result. Disagree: I disagree with the phrase "maps exactly one output to each output"—this appears to be a typo or mix-up in wording. It should likely say something like "maps exactly one output to each input." As written, it's unclear and could confuse students by implying outputs are mapped to outputs instead of inputs mapped to outputs. Would you like help clarifying the phrasing for a student-facing definition?

**Student:** I'm a preservice high school math teacher. Here is my definition of a function: A relationship between input and outputs that maps exactly one output to each output. Tell me 1 thing you agree with and 1 thing you disagree with. Do not just give me your definition of function.

**ChatGPT:** Agree: I agree with your emphasis on the idea of exactly one output, which helps reinforce the importance of functions being predictable and consistent—each input must lead to a single result. Disagree: I disagree with the phrase "maps exactly one output to each output"—this appears to be a typo or mix-up in wording. It should likely say

something like “maps exactly one output to each input.” As written, it’s unclear and could confuse students by implying outputs are mapped to outputs instead of inputs mapped to outputs. Would you like help clarifying the phrasing for a student-facing definition?

ChatGPT made note that the working definition of this student, their concept image, was not the one they should expect or instill in high school students. This student took this feedback and began reworking their definition to better suit it for a high school audience. While there was a typo in their new definition, as pointed out by ChatGPT, it made the student reflect on the word choice they would have when working with high-school students. This showed that the LLM responds to the goal of the learning task of students refining their conceptual definitions, while also attending standard issues of definition.

## 4 Student Learning Outcomes

This activity served as a review opportunity for several students. One student made note in their reflection, “I will admit chat taught me the official definition of a polygon, because if I’m being honest, I never actually had a fully thought-out definition in my head.” This task allowed for a review of the words they had already encountered in a novel fashion, and that allowed the students to target parts of the definition they may have not paid attention to initially in their concept image.

For the students in classroom B, there was an emphasis on specificity of domain and codomains in their definitions, which they were able to review as they worked refining their definition. More importantly this task showed, as the student who had to refocus their defining for the high school audience realized, the definition used for a particular term will vary from context to context.

## 5 Discussion and Implications for Practice

This was proof of concept for a prompt-structured task approach to using ChatGPT in the mathematics classroom. Unexpected challenges and unintended consequences arose as they were put into practice, but its implementation accomplished several of the goals laid out by the authors.

### 5.1 Emergent Benefits

One goal for this task was to instill in students a manner of thinking that would be productive when engaging with ChatGPT. This task, beyond simply being used as a vocabulary drilling exercise, pushes students to reason critically when engaging with LLMs. As opposed to seeing ChatGPT as a dispenser of absolute knowledge, they begin to build the habit of using it as a tool to refine thinking. One student appreciated this aspect of the activity, reflecting that they enjoyed working with “ChatGPT because it gives you a perspective of questions you don’t typically ask yourself.” This activity also showed holes in definitions the instructor had not anticipated. For their second attempt with the task, a student chose to define a line segment. Their initial definition was that it was “a part of a line that had two endpoints”. When ChatGPT was asked to generate a question, it asked “How does a line segment differ from a ray, and could you clarify that in your definition?” The student asked the instructor for clarification, and the instructor deduced that the LLM meant that a line with a segment removed had two endpoints and was part of a line. Whether this was the intention of the question or not, it served to give a perspective to the definition that even the instructor had not thought to address. Another student noted it was “beneficial to start gathering ideas to better construct a concept,” and went on to say, “Using the question and response method helps me with trying to connect new ideas to old ones to better my already existing understanding of the topic.” This was reflected by another student who said “I liked this activity because using chat gpt allowed me to refine my definitions and think more

precisely on how I worded my responses” Beyond simply pushing mathematical concepts, as shown in the recursive loop student, this activity targets the way definitions are made, which are not generally addressed in the context of mathematics courses. Beyond this, it pushed the scope for students to examine what the purpose of definitions were.

## 5.2 Emergent Difficulties

As discussed earlier, one student took advantage of the LLM to construct a definition by soliciting the parts they had to improve. In their reflection, they claimed to find the questioning method more usable, because it helped them more narrowly determine how to refine their definition. That calls into question if this student understood the intent of the assignment, or if he simply saw it as just an assignment, he wanted to get out of the way. This mentality appeared again with the student who claimed to have learned the “official” definition of a polygon. It needs to be made explicitly clear that the intent behind the task is not for them to uncover an absolute definition for a term, but to use this task to refine their definition into something stronger, even if not perfect. For some students in class A, this was their first time using the LLM. One student found frustration with the task, feeling that the LLM was posing unnecessary challenges to a word they already felt familiar with. Another student wrote in their reflection about their mistrust of AI as a resource, which stemmed from their English teachers warning them of plagiarism. Student concerns about AI reliability, plagiarism, and ethical use are often well-founded and reflect broader professional debates in education (Edwards, Yang, and Lopez-Gonzalez, 2024). Rather than treating skepticism as a deficit to be overcome, this task positions such concerns as productive starting points for critical engagement. While LLMs have become increasingly visible in educational spaces, preservice teachers may reasonably arrive at different conclusions about when, how, or whether such tools belong in their own practice. This task is not intended to mandate AI use, but to support informed, reflective decision-making for those who choose to engage with these technologies. There were other pockets of frustration with the complexity of the task. In one reflection, a student noted it was “frustrating at points with how many questions it would ask to make my definition clearer”. Another student struggled as their definition only became more convoluted, “I didn’t like the feedback it gave me as it made the definition lengthier than it needed to be to get the point across. [...] It also kept telling me to add things then complained about it not being concise.” Another student expressed similar frustration, claiming “it asked multiple questions about the same thing that I feel like I already made clear.” As shown in the student examples, students went off script to seemingly simplify the task. There was redundancy in the prompt structure, which led to these frustrations. One final difficulty that arose in this task, and the most instrument-based one, was the matter of accessibility. Initially, when the task was done with classroom A, many students struggled with being able to run the LLM. A prediction was made that it could be that having everyone in the classroom run through the LLM simultaneously drew too much traffic on the network. Even once everyone was able to access the LLM, some students found that they could no longer enter prompts as they had hit a limit. Several students wrote in their reflection that this prevented them from fully completing the task.

## 5.3 Ethical, Environmental, and Reliability Concerns

Despite the instructional practices of LLMs, their classroom use raises important ethical and practical concerns. First, data privacy remains an unresolved issue particularly when students unknowingly share identifiable information or when conversation histories are stored outside instructor control. Second, algorithmic biases embedded in training data can shape feedback in ways that privilege dominant linguistic norms or mathematical framings. Third, the environmental costs associated with training and running LLMs, especially with energy consumption, present concerns for educators

attentive to sustainability. Finally, reliability issues persist, including the potential for incorrect feedback, plagiarism, or over-reliance on LLM-generated language. These limitations underscore the importance of framing LLMs as provisional tools, as opposed to knowledge-granting authorities.

## 5.4 Going Forward

Accessibility will be the greatest obstacle. As AI becomes more integrated in the classroom, there may be a need for partnerships so that schools can set up accounts for their students. Until then, this task can still be carried out and run within a classroom. OpenAI has implemented a “temporary chat” feature, which prevents any conversations used with ChatGPT from being stored or used by the company to train their models. This feature should be used by students when using the LLM within the classroom. However, students should still share transcripts of their conversations with their teachers. This way, a teacher can quickly evaluate the steps the students took to refine their definition and see if there is anything that needs to be addressed. There was no clear preference by students on whether the questioning or feedback strategy felt more beneficial for them. Students gave mixed reviews. As mentioned earlier, some students appreciated the questioning method, believing it to be straighter to the point compared to the feedback method. Other students, however, claimed they “liked the feedback one better because sometimes the questions it would ask didn’t really make sense to me.” Affective attitudes also began to appear in the questioning strategy, with students commenting “ChatGPT was also very sassy for some reason” and “The question version felt almost judgmental.” Ultimately, research has to be carried out to see whether one strategy is more effective than the other. This task facilitated connections to broader pedagogical themes. It begins to introduce students to more nuanced understandings of definition, as shown by the student who realized the word they were defining could not be included in their definition. As seen with the student example from classroom B, this task also introduces students to the idea that words can change meaning based on context. One student suggested that they would “ask shorter questions to chat gpt if [they] were to assign this because [they] feel like the more words you put into it the more you’ll get back and it’s just a bunch of run ons.” This was likely done in response to the same frustration her peers felt with the redundancy of the task structure. Instructors should not discourage students from modifying the prompt structure in a way the student sees fit, but they should ensure the modifications do not inhibit the objective of the task to encourage critical reasoning in students as they work with definitions. This is a possible trajectory for future research—as researchers seek to develop instructional products in the LLM space, they should attend to the ways students might use LLMs outside the scope of the product.

## 6 Conclusion

LLMs have entered the public sphere. It is our responsibility as educators to prepare our students to engage with this technology responsibly and in a way that will prepare them forward in their lives. This is proof of the concept of the task, and the pilot participants in this article were pre-service elementary and high school teachers. This is not to say that the task was meant specifically for these students or undergraduates. The natural language used in the task could make it so that students across all grade bands find easy entry to the task. Simultaneously, the fact that the task is open-ended without a definitive end goal means that students have a high ceiling to push their reasoning.

This prompt-structured task has served to encourage students to reason critically with the use of LLMs. Examining student conversations showed how student definitions developed as they went through the refining strategy. Here ChatGPT did not act solely as a dispenser of information, but as an interlocutor who collaborated with the student to facilitate conceptual learning. The findings from these pilot trials reveal that LLMs can serve to find gaps in mathematical understanding, promoting nuanced and thought-out reasoning when working with mathematical definitions.

The successes and difficulties that arose from our project reaffirm the need for research in integrating LLMs and related software in the classroom, but it also shows educators can start to embrace the technology in their classrooms. Going forward, we advocate for a push in rewriting LLM's role in education, emphasizing that doing so will prevent the technology from falling into the role of academic disruptor that has already been applied to it. Creating activities like the one presented here will form habits of mind that will help students as they find themselves in a more AI-driven world.

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