

Western Digital®

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**VALUE OF DATA**  
**TEACHING THE**  
**FUTURE WITH AI:**

**Can Humans and Machines  
Work Together to Solve  
the Education Crisis?**



**Would you be comfortable if our children were taught by machines in school? Some might not be so sure, but that day isn't far off. And it's a day that carries tremendous promise to address the current education system's difficulty in accommodating a wide range of diverse students and how they learn—and, in the process, leads to giant leaps in learning.**



Imagine, for example, a hypothetical student named **Roseline, who has always struggled with math**. Now in her final year in secondary school, she's in danger of failing to graduate if she doesn't pass a required math class she's already repeated once. If that happens, she'll most likely give up and drop out of school.

**But this year is different because Roseline's school has adopted several artificial intelligence (AI) solutions to improve and tailor the student learning experience.**

The classrooms have microphones and cameras to analyze students' engagement and emotional reactions to topics taught in class, which shows teachers which topics require additional emphasis. Combining an AI-based content curation system with student data, teachers can identify from a global database the best material and strategies to use in the classroom. Roseline will also be completing homework on an AI-based adaptive platform that will tailor questions and provide real-time feedback, like a tutor, based on her class participation, responses to questions, and individual learning style.

With AI underpinning a lot of what and how she learns, Roseline finds it easier to understanding the math concepts she needs to pass the class, as well as graduate. As a result, she'll have a better chance of finding a job and will likely earn more than if she dropped out of school—as will millions of other students like her.

It's not just Roseline alone. **In fact, by 2040, AI can help an additional 110 million students complete upper secondary education, fill over 3.3 million additional jobs, and generate over \$342 billion through increased wages.** AI can also improve the training provided to teachers while reducing costs over the same time horizon, releasing over \$748 billion to be reinvested into the school system.

# THE CONSEQUENCES OF ONE-TO-MANY EDUCATION

**Roseline’s struggle is one that plays out over and over in school districts around the world. That’s because many classroom teachers can’t address students’ diverse learning needs, learning styles, and pace of understanding.**

Some teachers simply don’t have the skills or training to individualize education. According to the World Bank, if education systems aren’t committed to hiring and developing teachers skilled in particular subjects, new teachers can find themselves in classrooms with little mastery of the content they’re supposed to teach.<sup>1</sup> Once in place, teachers often get inconsistent or overly theoretical professional development. And in some countries, the enormous cost of training—which, for example, is \$2.5 billion a year in the United States<sup>2</sup>—can be an obstacle.

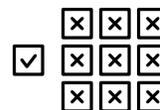
Furthermore, the growing size of classes can present a challenge for even skilled teachers. According to 2015-2016 data from the World Bank, the average primary school pupil-to-teacher ratio in the least-developed countries (by UN classification) is 38:1 and roughly 41:1 for low-income countries.<sup>3</sup> Fully addressing students’ individual needs in such circumstances is nearly impossible.

When students don’t get the individualized attention they need to succeed—particularly if they are disadvantaged socioeconomically or have learning or other disabilities—they often drop out or don’t even start school.<sup>4</sup> In fact, one study found that 90% of students with learning disabilities who repeated a grade ultimately dropped out of school.<sup>5</sup>

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# THE GAME-CHANGING POWER OF AI

**This is where AI holds huge promise. AI is defined as applications that can sense, comprehend, act and learn leveraging machine learning, natural language processing and computer vision to automate and augment human activities.**

AI, and the personalized learning it fosters, can fundamentally change how education is delivered, make education more accessible, and improve the rate of upper secondary school graduation. Imagine a not-too-distant future where AI-based instruction dominates education and communities realize the economic benefits: lower unemployment, higher wages, and more money that can be reinvested into schools.

AI lets machines interact naturally with people, data, and the environment. It creates more intuitive interactions and extends what either humans or machines can do on their own. AI can understand contexts, recognize emotions, faces, sounds, and handwriting. It can analyze large amounts of data collected from the individual student, other students in the classroom, and the teacher to recommend, translate, and modify content while continuously improving upon itself to generate greater long-term results.

Thus far, according to Gartner, AI has penetrated just 1% of educator, student, educational institution, and publisher markets, collectively.<sup>6</sup> But Gartner also projects that AI will play a transformational role in education within the next five to 10 years, and that role is on the cusp of exploding. Three scenarios illustrate AI's game-changing potential:

## THREE SCENARIOS ILLUSTRATE AI'S GAME-CHANGING POTENTIAL:

**01** Helping teachers

**02** Personalizing the learning experience

**03** Enhancing third-party learning content

# SCENARIO 1

# HELPING TEACHERS

## AI and teachers can work side-by-side to make teaching more effective.

For instance, facial and voice recognition and emotional analysis can **measure students' engagement** and emotions and determine their attention, understanding, and confidence. At North Carolina State University, researchers used facial recognition software to determine which students were having trouble with learning material, as well as which ones found it too easy.<sup>7</sup> Such insights can help teachers pick the right content or teaching strategy for each student.

Another example is [Third Space Learning](#), an online math tutoring platform that debuted five years ago, which is capitalizing on the huge store of student-teacher interaction data it has collected from millions of lessons. The company has [launched an AI project](#) through which it's analyzing all its data to **find the most effective teaching interactions and learning patterns** so it can empower teachers to become even better educators in the classroom. The platform is growing rapidly: Since starting, nearly 350 UK schools have already enrolled nearly 6,000 struggling students in Third Space.<sup>8</sup>

AI also **enables teachers to access the best content available globally**, and personalize it to individual students in their local language. In fact, machine translation can transform content from anywhere in the world in any of the more than 7,000 living languages, vastly expanding the universe of materials available to teachers. [K4All](#) is already working on creating an online international educational market free of language barriers, with the intent to deliver automated high-quality translation in the most relevant use situations for at least 50% of developing-country languages by 2025.

Combining an AI-based content curation system with student data, teachers can identify from a global database the best material and strategies to use in the classroom.

## SCENARIO 2

# PERSONALIZING THE LEARNING EXPERIENCE

**AI-based tutoring and guided content that adapts according to student learning styles, needs, and engagement can help students learn at their own pace.**

For example, adaptive homework or learning aids can tailor assignments or content to align with a student’s understanding, moving away from “one size fits all” homework and providing better coaching and tutoring. This is especially helpful for students with learning disabilities. AI can replace complicated words or expressions with language such students better understand, and gradually introduce more complicated language as students demonstrates subject mastery.

AI-based solutions such as social network [Brainly](#) also can foster self-education by helping more than 100 million students collaborate by posting and responding to nearly 8,000 questions per hour on the Brainly platform.<sup>9</sup> Brainly, in turn, uses machine learning algorithms to automate content moderation and AI algorithms to personalize its networking features. For instance, Brainly will make friend suggestions to students based on the subject areas with which they appear to need the most help.

Another company, [Content Technologies Inc. \(CTI\)](#), is leveraging deep learning to assemble custom textbooks.<sup>10</sup> After educators import their syllabus and material into CTI’s engine, the system analyzes the content to create books and core concept material that are tailored to each class based on what they’re expected to learn. That’s a task CTI claims it can do with a staff of 20 but would require large publishers thousands of employees to replicate.

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## SCENARIO 3

# ENHANCING THIRD-PARTY LEARNING CONTENT

**Online adaptive learning platforms have made huge strides in the past few years.**

AI turbocharges such third-party tools by personalizing the experience: understanding how a specific student is interacting with the platform and recommending the right content for each student to ensure the student is learning. AI can determine, for instance, if a student benefits from gamification of learning content versus watching an interesting video—and it can determine what the student considers “interesting.” Research by [Whizz Education](#) shows that just an hour a week spent with the company’s AI-powered tutor over the course of an academic year can accelerate a student’s learning by 18 months.<sup>11</sup> When content matches a user’s culture and preferences, the reach of existing materials, as well as good teaching content and methods generally, expands dramatically.

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# A TIERED APPROACH TO ADOPTION

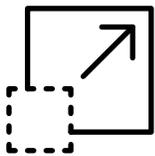
**The preceding examples really only scratch the surface of what's possible when AI becomes an integral part of the learning experience.**

But broad adoption probably won't happen as quickly as most parents and students would like. Instead, AI applications in education will likely be introduced in a measured way, across three broad phases or levels of maturity.



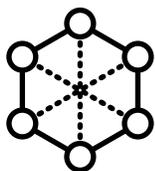
## 01

Tier 1 is **highly tactical**. With insufficient collection of student data limiting machine learning and AI hardware costs still high, students will be restricted to using primitive adaptive learning tools. Teachers, as well, will be limited to sourcing content based mainly on their input, and very limited student data.



## 02

At Tier 2, digitally enriched classrooms build the foundation for broad scale AI applications. Advancements in data privacy policies and AI capabilities will foster more comprehensive collection of student data to improve education, and continually declining AI hardware costs will fuel an **expanding use of AI**. Classrooms will be fitted with video and audio capture equipment, handwriting recognition tools, and possibly integrate with available wearable technology to support analysis of student and teacher actions and interactions. As a result, students will get more-sophisticated AI-led assignments and supplementary content to compliment classroom learnings and teachers can tap into much larger data sets and real-time analysis to create a more customized learning experience for students.



## 03

Tier 3 will be characterized by a **connected educational platform**, which will immensely transform the learning experience. A strong foundation of student-based data and AI, combined with supporting technological advancements, will further accelerate AI use.

AI will utilize student-specific learning data from multiple sources to manage the end-to-end learning experience for each individual student. Students will benefit from personalized content as well as personal virtual assistants that support their learning within and outside the classroom. The role of teachers will also evolve. Teachers will use AI for providing the learning content and serve as mentors to students, ensuring each student is meeting their own personal learning objectives. Commoditization of key cost components will expand the reach of AI applications in education globally, making high quality education more accessible among underserved populations.

As AI and its supporting technologies continue to advance, their applications in areas like education will increase exponentially. With movement from each tier of adoption expected to take approximately six years, AI could completely transform education around the world by as early as 2036.

**By 2040, classrooms can generate over 34 billion hours of video and audio data that can be used for analysis by AI each year.**

# WHAT'S THE VALUE?

**In developed countries, technology has already had huge impacts on the classroom learning experience—from smart boards and laptops to virtual reality experiences.**

Technology costs are declining and free online resources are growing, making educational technology within the reach of many more school systems and students. But most of today's educational tools don't adjust for different cultures, languages, or individual learner needs. And content geared toward an accelerated learner may not work for those needing to move at a slower pace. AI can help schools take that next step: radically redefine how education occurs and promote giant leaps in learning.

**Of course, investment will be required for AI to take a front seat in education. But the potential economic and social benefits create a case for action that's difficult to ignore:**

**01** Better educational outcomes

**02** Improved quality and scalability of teacher training

## **BENEFIT 1**

# **BETTER EDUCATIONAL OUTCOMES**

### **Drop-outs are a massive challenge across school systems today.**

Drop-outs are a massive challenge across school systems today. More than 31 million youth and young adults in upper-mid to high-income countries aren't in school; the figure rises to more than 194 million in developing countries.<sup>12</sup> As AI improves the educational experience for students, upper secondary school graduation rates will climb, which will translate into lower unemployment and higher wages. Research has found individualized learning interventions (either via tutoring or in the classroom) can boost upper-school class passing rates by 2.2%.<sup>13</sup> At the college level, such interventions can increase passing rates by up to 7%<sup>14</sup> and, over an extended period, by up to 29%.<sup>15</sup> Multiple studies, including that by the Organization for Economic Co-operation and Development (OECD), also show that higher education correlates with a greater chance of employment and higher earning potential. For instance, in 2016 the OECD found the unemployment rate of individuals who completed upper secondary education in upper-mid to high-income countries was approximately 5.7%, compared with 8.8% for those with below upper secondary education.<sup>16</sup> By 2040, with the help of AI, more than 110 million students could receive the additional support they need to complete upper secondary education, fill an additional 3.3 million jobs, and generate more than \$342 billion in incremental value through earned wages. It's worth noting that while many of those who complete upper secondary education are likely to continue to seek higher levels of education, for the purpose of this paper, we assumed that these individuals would end their educational pursuits and calculated their incremental wages accordingly.

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## BENEFIT 2

# IMPROVED QUALITY AND SCALABILITY OF TEACHER TRAINING

**In addition to improving individual outcomes, AI can improve school systems' bottom lines.**

UNESCO estimates that [more than 24 million primary school teachers need to be recruited](#) and trained to achieve universal primary education by 2030, while a further 44 million secondary school teachers will be needed. More than 80% of the new primary teachers will replace retiring staff. AI can improve the quality and scalability of training all those new teachers as well as existing ones. That's a big benefit considering current training is typically only marginally effective yet extremely costly for many school systems. For instance, one study found that after participating in training, about one-third of teachers improved in their evaluations over a two- to three-year period, but 20 percent actually got worse.<sup>17</sup> AI can improve teachers' performance by helping them access the best resources and teaching methods for their specific students, thus minimizing the need for other, less-effective (and costly) training activities on the topic. AI also could improve the effectiveness of teacher training in much the same way it improves student learning (an important topic, but one that's outside the scope of this paper). The value of these changes alone for upper-mid to high-income countries, collectively, can amount to more than \$748 billion by 2040, which can be reinvested into the school system and teachers.

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# MAKING PERSONALIZED EDUCATION A REALITY

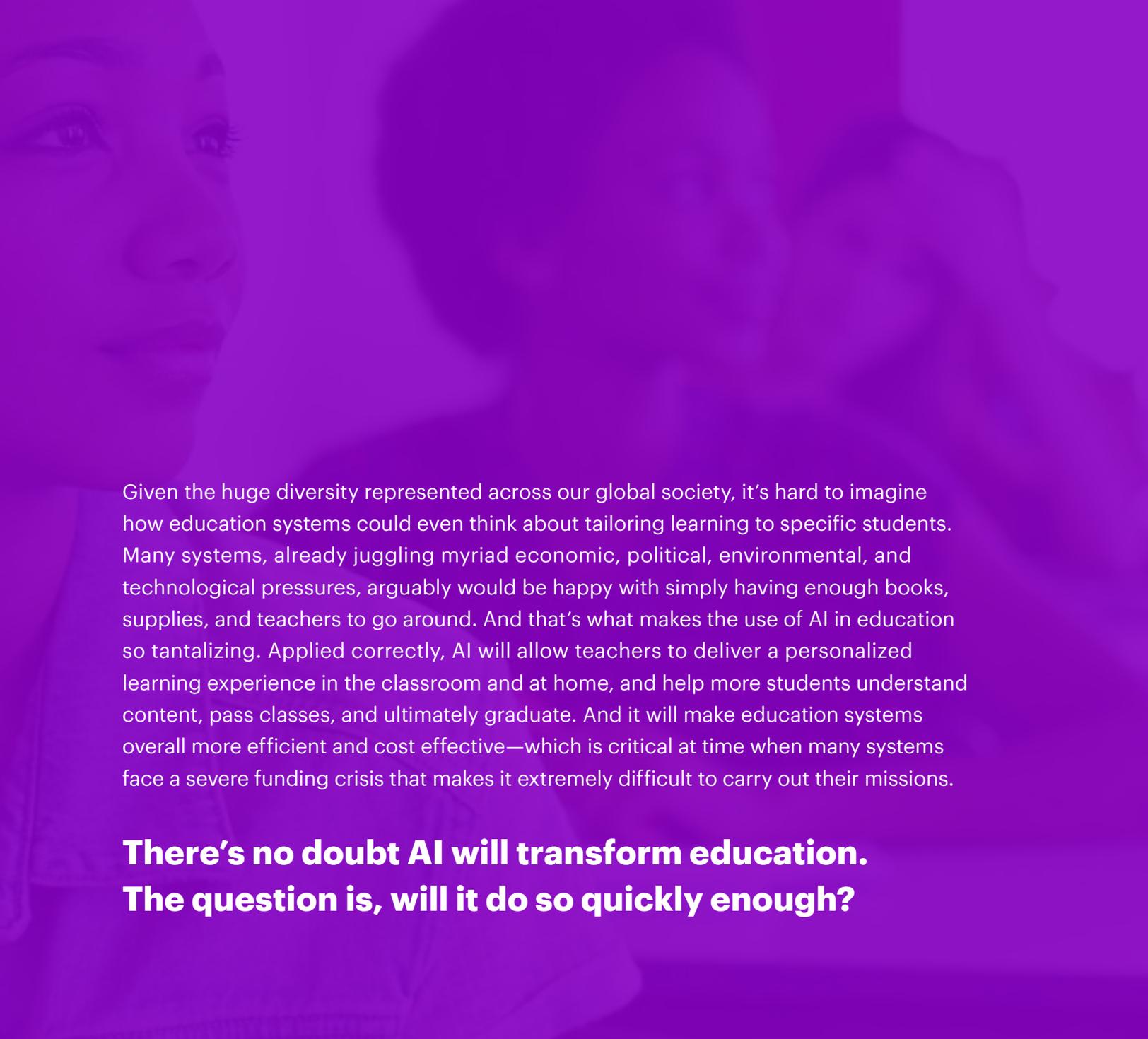
**With AI capabilities expanding and the costs of computing power declining, society finds education on the cusp of transformation.**

That said, three important considerations should be at the top of the agenda of any initiatives to make greater use of AI in the education system. The first, and arguably the most important, is **personal privacy**. Parents naturally aren't comfortable freely sharing data on their children without a strong understanding of why it's needed. Yet data is the foundation of effective AI-based tools. Thus, for AI to flourish, school systems need to provide a clear and understandable value proposition to families; employ sophisticated tools and practices to maintain and protect student data; and operate with complete transparency.

Second, both AI developers and educators must remain cognizant of **bias**. If the data on which the AI system is trained is geared toward a certain demographic (race, economic tier, or culture), the output will be biased. This is a real concern when there's a disconnect between how and where the AI is trained relative to the demographic of the school district that's using it. On the positive side, if AI is trained properly, its inherent objectivity can help overcome bias in the classroom—perhaps even more so than teachers can do themselves.

Finally, with schools increasingly collecting massive amounts of data to inform the education process, **data storage** becomes a major concern. As AI applications gain momentum in education, the amount of additional storage capacity needed per year could skyrocket to 8.6 billion gigabytes (8.0 exabytes) by 2040.

**As AI applications gain momentum in education, the amount of additional data management needs per year could skyrocket to 8.6 billion gigabytes (8.0 exabytes) by 2040. That's just about 1 petabyte per hour, equivalent to over 96x the estimated amount of all content on Wikipedia.**



Given the huge diversity represented across our global society, it's hard to imagine how education systems could even think about tailoring learning to specific students. Many systems, already juggling myriad economic, political, environmental, and technological pressures, arguably would be happy with simply having enough books, supplies, and teachers to go around. And that's what makes the use of AI in education so tantalizing. Applied correctly, AI will allow teachers to deliver a personalized learning experience in the classroom and at home, and help more students understand content, pass classes, and ultimately graduate. And it will make education systems overall more efficient and cost effective—which is critical at time when many systems face a severe funding crisis that makes it extremely difficult to carry out their missions.

**There's no doubt AI will transform education.  
The question is, will it do so quickly enough?**

## LEARN MORE

To learn more about how data is transforming the way students learn in the classroom, visit [Data Makes Possible](#).

To learn more about how technology is innovating the student experience, visit [Accenture](#).

To learn more about AI: The Momentum Mindset, visit [Accenture Strategy](#).

# APPENDIX A: THE VALUE OF ARTIFICIAL INTELLIGENCE ON THE GLOBAL ECONOMY

## ASSUMPTIONS

- All countries classified as upper-mid to high-income countries by the World Bank will have the financial means to implement AI in their education system.
- The population of students entering primary school increases by 1.06% annually.
- At maturity, the continued application of AI through primary, lower secondary, and upper secondary education will result in an 19.8% increase in the average upper secondary completion rate.
- Each additional student who completes upper secondary school will have a 94.2% chance of employment with an annual income of \$26,341, which will grow at the global inflation rate of 3.05% annually, compared with a 91.2% chance of employment and an \$18,815 annual income for those with less education.
- AI's application in primary, lower, and upper secondary education will reach maturity by 2036.

## VALUATION APPROACH

### Value Driver

### Approach

Increased employment and wages through higher upper secondary completion rates

Number of students eligible for graduation  
 x Increase in graduation due to AI  
 x Increase in employment due to higher education level  
 x Increase in wages based on higher education level

### Total \$ Benefit

Cost savings associated with using AI for teacher training through improved content curation and teaching approach

GDP for countries considered  
 x % of GDP spent on education  
 x % of education spend allocated to training teachers  
 x % reduction in spend achieved by using AI in class

### Total \$ Benefit

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