Interrogating Data to Explore Digital Inequity

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Abstract: *The mathematics classroom should be an environment where students explore core social issues. In this article, I propose a lesson using the GAISE II framework that can be implemented into a statistics classroom. The lesson allows students to learn about the four components of the statistical problem-solving process (Formulate Statistical Investigative Questions, Collect/Consider the Data, Analyze the Data, and Interpret the Results) as they interact with real-world data. The Federal Communications Commission (FCC) created an interactive website that can serve as a technological tool for teachers to implement in the mathematics classroom (www.broadbandmap.fcc.gov). The website allows users to explore broadband accessibility across the United States, highlighting disparities in accessibility. Teachers can use the FCC's online interactive tool to give students practice with data analysis while simultaneously enlightening them to issues of digital equity.*

Keywords: *statistics education, quantitative reasoning, social justice, broadband access, GAISE report*

Introduction

The mathematics classroom should be an environment where students explore core social issues. Investigating real-world data that highlights these issues can be a way for students to engage in statistical problem-solving while simultaneously learning about relevant social justice topics. One of the many social issues that students can become aware of in the mathematics classroom is digital inequity. This article presents a lesson that teachers can implement in their classrooms to build their students' statistical reasoning while also educating them about critical facets of the digital divide. Using GAISE II as a framework, this lesson gives students opportunities to examine real-world data through the utilization of web-based digital media. Strategic use of this tool can engage students in the process of data analysis while simultaneously supporting their skills in problem-solving, reasoning, and justification.

Broadband Accessibility

National Council of Teachers of Mathematics

In their position statement on the use of technology in the teaching and learning of mathematics, the National Council of Teachers of Mathematics (NCTM) highlights the importance of providing students with accessible technology that promotes their sense making, reasoning, problem solving, and communication (NCTM, 2011).

Broadband Map Website

The Federal Communications Commission (FCC) created an interactive website that can serve as a technological tool for teachers to implement in the mathematics classroom www.broadbandmap.fcc.

gov). The website allows users to explore broadband accessibility across the United States (FCC, 2020). Broadband is a high-capacity transmission that provides high-speed internet access. The FCC's website displays data that was collected from broadband service providers on FCC Form 477 to illustrate various facets of deployment across the country. Users can choose from a list of technologies and internet speeds to generate maps and graphics that visualize data in different geographical locations. This data consists of non-traditional variable types that can generate statistical questioning in students, while also giving them insight into the issues of the digital divide.

The Digital Divide

Background of the Problem

Our nation is facing a growing digital divide, and poverty has played a central role. For decades, there have been disparities in digital accessibility between residents at opposite sides of the financial spectrum (NTIA, 1995; NTIA, 1998). The expansion of the internet has accentuated these imbalances over the years. Low-income neighborhoods in rural areas and central cities lack the necessary infrastructure required to generate reliable broadband internet. Part of the problem is that many of the households in these neighborhoods are financially incapable of affording the premium packages offered by broadband internet providers. Without the accountability of federal regulators, these providers can restrict their services to the most affluent areas (Seitz-Brown & Mabud, 2017). This is an equity issue, as broadband internet providers can choose to bypass these communities because of their financial situations.

Relevance to Students

Although this problem may be invisible to some students, providing them with opportunities to examine data that highlights these disparities can open their eyes to issues related to digital inequity while simultaneously supporting practices of statistical analysis.

Framework for considering Data Literacy in Lessons

The GAISE II Framework

Pre-K-12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II) lays out a curriculum framework for Pre-K-12 educational programs to help students achieve data literacy and become statistically literate (Bargagliotti et al., 2020). This framework emphasises the importance of inquiry throughout the four components of the statistical problem-solving process (Formulate Statistical Investigative Questions, Collect/Consider the Data, Analyze the Data, and Interpret the Results). This four-step process gives teachers a clear outline to build lessons for data science and statistics courses. The GAISE II framework is designed to support teachers in building students' statistical literacy through engaging lessons ingrained in real-world contexts.

Levels of Statistical Reasoning

GAISE II identifies three levels of students' statistical reasoning (A, B, and C). The four-step statistical problem-solving process is incorporated throughout all three levels.

Level A

At Level A, students develop a general sense of this process as they are introduced to the concept of data. Students formulate their own statistical questions about the world around them. They begin to collect and analyze data as they set out to answer these questions.

Level B

At Level B, students further their understanding of the statistical problem-solving process by learning about different types of variables in data sets. Students explore more in-depth statistical investigative questions that involve possible associations between variables. There is greater emphasis on the interpretation of results, as Level B students look for comparisons between samples of populations and changes over time.

Level C

By the time students are reasoning at Level C, they have developed a sophisticated understanding of the statistical problem-solving process that allows them to effectively determine appropriate data analysis tools, account for errors in data sets, and engage in multivariable thinking.

Progression Through the Levels

The GAISE II framework does not explicitly connect standards to specific grade bands, as students may have drastically different statistical reasoning skills regardless of their grade level. The progression from the most basic level, Level A, to the most advanced level, Level C, can vary in time depending on the student. Therefore, it is important to differentiate instruction to meet the needs of students who may be reasoning at different levels. The FCC's website offers entry points for students at multiple levels of the GAISE II framework. Specifically, the following lesson is designed to support statistical literacy of students who are reasoning at Level B or Level C.

Lesson Details

Step 1—Formulating Statistical Investigative Questions about Equitable Broadband Access

The first step of the statistical problem-solving process has a goal of producing answerable statistical questions. As students generate questions, they should take variability into account, which would lead to meaningful data collection processes. To promote questions that will lead to productive statistical investigation, students should be given time to explore the features of the FCC website that are directly related to equitable broadband access. Students can use the "Area Summary" tab to gain an understanding of broadband deployment in different regions across the nation. This tool gives students access to an interactive map of the country (see Figure 1) displaying regions with varying numbers of broadband internet providers.

Teaching Ideas with the Site

The variety of features that students may interact with in the FCC website can raise questions for students. Level B students may need assistance with the utilization of inquiry to guide their statistical thinking while Level C students may begin composing their own answerable statistical questions based on their initial conclusions about broadband access availability. To support Level B students, teachers can point out patterns in the data. Video 1 (see Figure 2) demonstrates some of the noticings and wonderings the website can stimulate. The color scheme used on the maps highlights similarities and differences between regions.

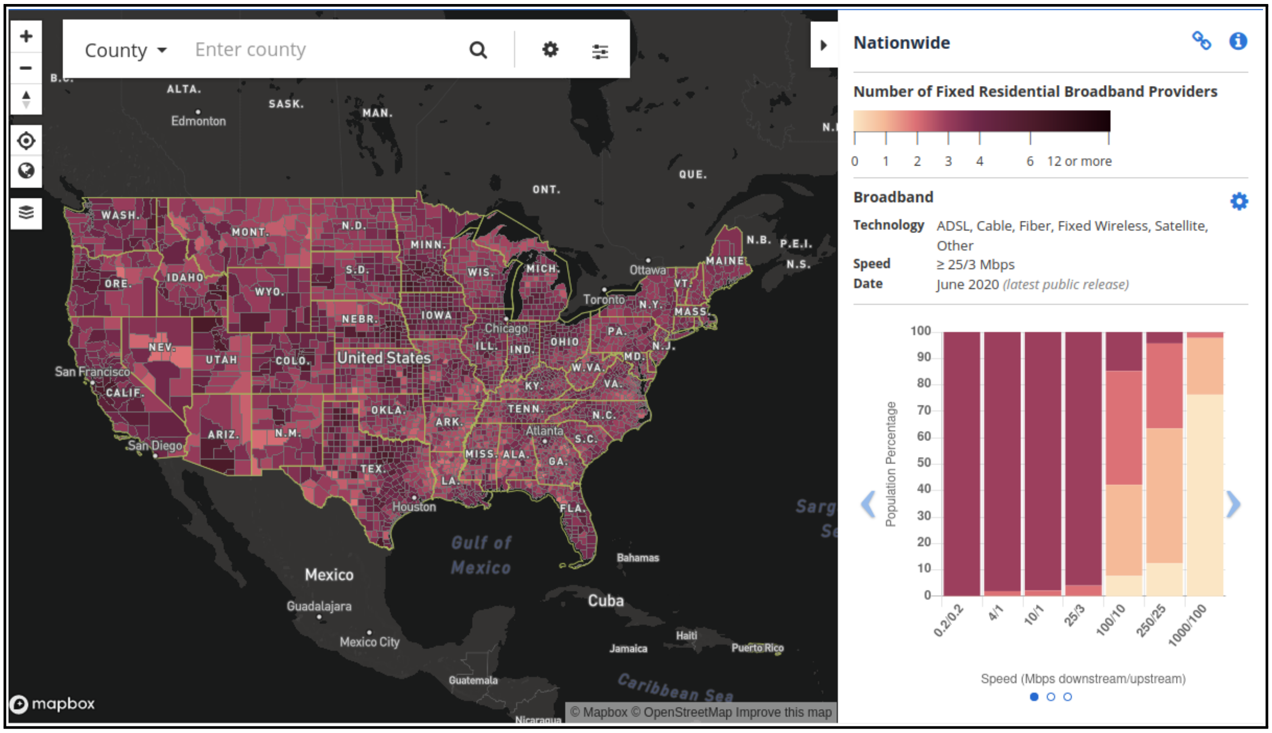

Figure 1: *Number of Broadband Providers: Country View (Source: https://go.usa.gov/xMZPd).*

Directing students' attention to pockets of shaded regions and asking students about their noticings and wonderings can spark statistical inquiry. Additionally, Level B and Level C students may be unfamiliar with the meaning and location of urban, suburban, and rural areas. A discussion about the differences between these kinds of geographical locations may be necessary.

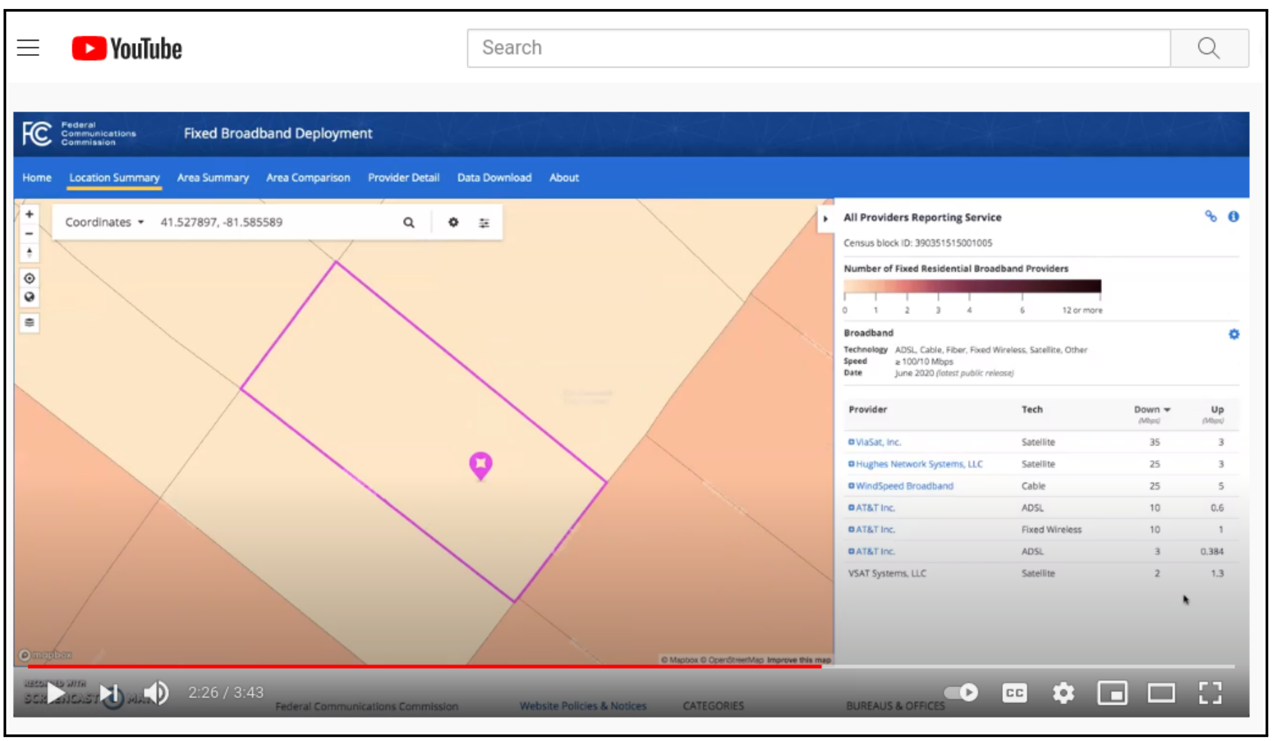

Figure 2: *Video demonstration (Source: https://www.youtube.com/watch?v=aHGztbEz0qY).*

To support students as they generate questions about the data, teachers may lead a class discussion in which students can share their thoughts and ideas. Teachers can formatively assess their students' generation of statistical questions during this discussion. Productive statistical questions consider variability in the data and can lead to rich data collection processes. If students struggle with formulating answerable questions, teachers may pose the following examples:

- Where do disparities in broadband access occur?
- What are similarities/differences in broadband access between urban, suburban, and rural areas?
- How does broadband access fluctuate across the United States?

Step 2—Collect/Consider the Data from the Website

After identifying their questions, students should proceed to the data collection process. The goal of data collection is to have students spend time looking for the variability in broadband access availability. Students may notice the variability not just across the country, but within states, counties, or even neighborhoods. This is where students can begin interrogating the data. It may make sense for students to explore their own community and state, where they likely have the greatest understanding of the urban/rural divide. Although the FCC website has already collected the data, students may spend time considering the complexity of the data, specific to particular regions. The website provides users with several variables (provider name, number of providers, type of tech, and speed) along with many different observational units (State, Country, Congressional District, Census Place, and Tribal Area). Level B students may begin the process of becoming attentive to these types of variables and investigate differences between them. Level C students may engage in multivariable thinking as they conceptualize the relationships between variables.

Step 3—Analyze the Data on Broadband Variability

Once the data have been considered, students may begin the analysis process. In this third step in the statistical problem-solving process, students transition from identifying variability to actually trying to understand it. Guided by their questions, they can use the FCC website to look for patterns in the data with the different levels of observational units. Students can investigate accessibility on different scales, using the varying shades of color on the maps to further understand the accessibility of broadband internet. Level B students will gain experience fluctuating between data that is drawn from different amounts of populations. Level C students may begin using the colored patterns on the maps to begin formulating hypotheses to answer their statistical questions. Figure 3 demonstrates an example of what students may notice when they fluctuate between these levels.

State and County Data

This particular situation displays broadband deployment across the state of Ohio (on the left). When analyzing the data presented on this state-wide image, students may notice that Ohio's larger cities are darker while rural areas surrounding these cities are lighter. Students may initially hypothesize that Ohio's cities have higher levels of broadband accessibility than its surrounding areas. However, if students further their analysis and zoom in on a particular county (such as Cuyahoga County, on the right), they may notice intriguing disparities within these larger cities. Inner-city Cleveland is shaded considerably lighter than its surrounding areas. In 2019, this city was ranked #1 as the worst-connected major U.S. city, with more than 30% of households having no broadband access (NDIA, 2020). In particular, East Cleveland has the least amount of accessible broadband providers along with the slowest internet speeds in the county.

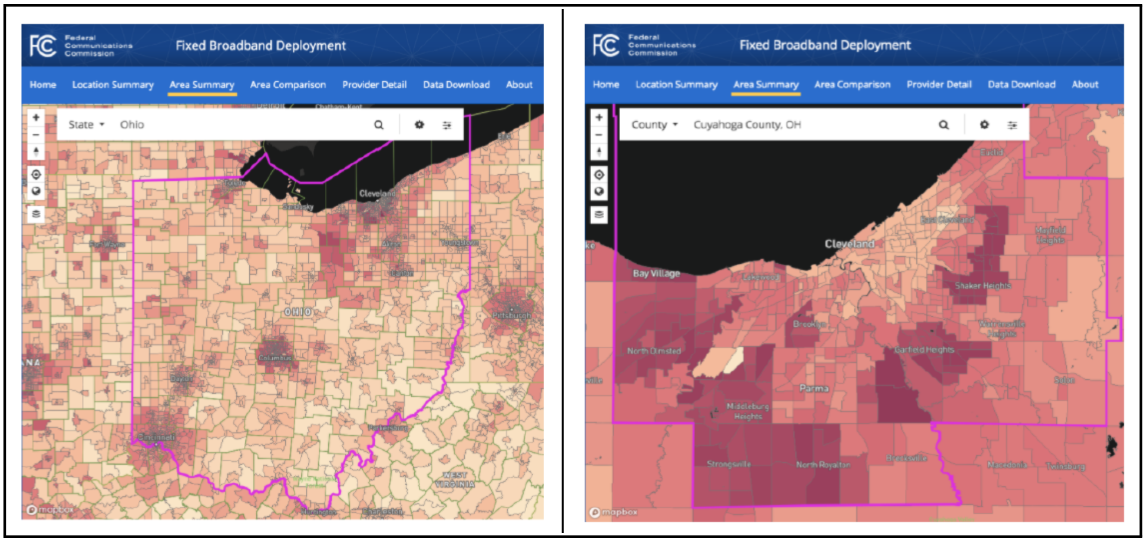

Figure 3: *Broadband Providers: State and County Views (Source: https://go.usa.gov/xMZmC).*

Selecting Neighborhoods

The FCC's website allows users to select specific neighborhoods across the country. This feature provides more detailed information regarding broadband deployment on a much smaller level. Figure 4 shows broadband details between two census blocks.

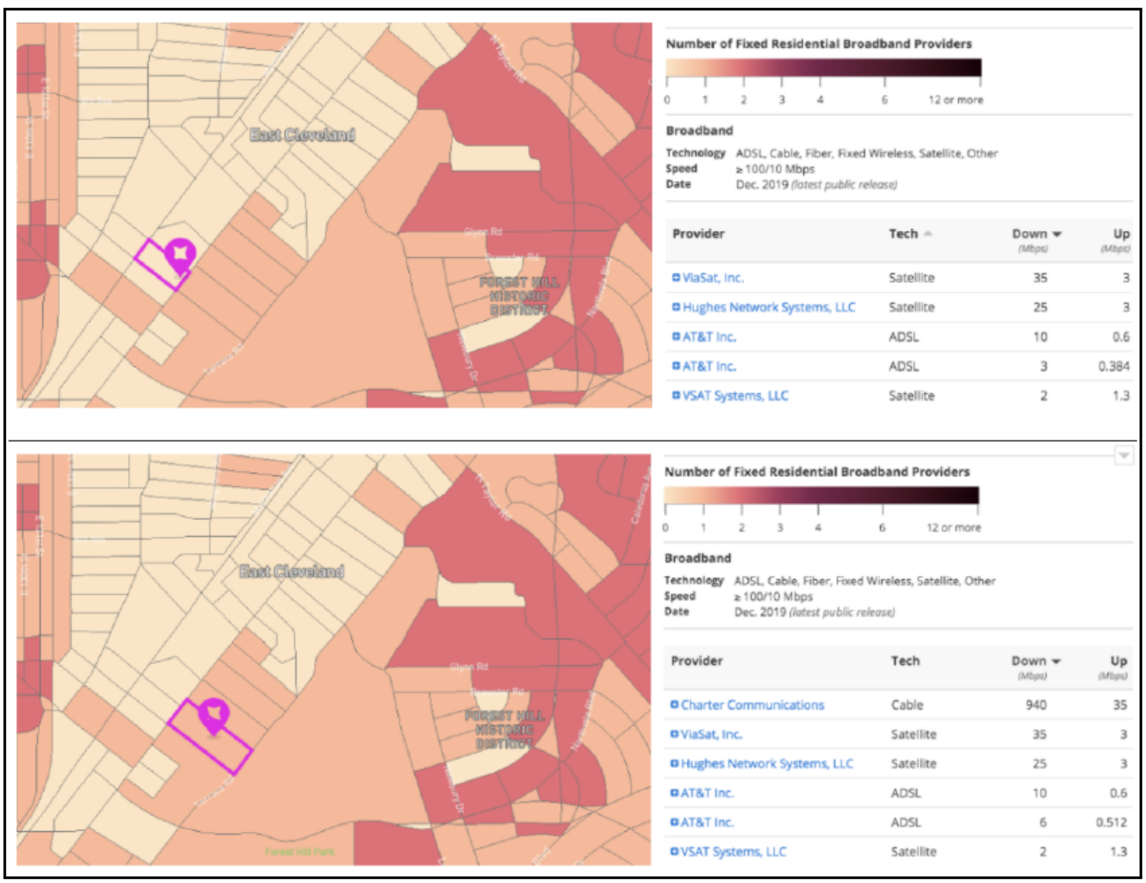

Figure 4: *Number of Broadband Providers: Census Block View.*

These are adjacent neighborhoods in East Cleveland. The first neighborhood (on the top) only has access to internet speeds up to 35/3 Mbps. It doesn't have the option to access broadband internet through a cable company. Satellite and ADSL are the only two options, and neither of these technologies have the ability to provide fast and reliable internet. Conversely, the second neighborhood (on the bottom) has access to a cable company that provides speeds up to 940/35 Mbps. Students may analyze the statistics provided by this tool to gain an understanding of the significant disparities between residential areas. Exploring issues such as these inequities in broadband availability through data analysis will provide students with opportunities to begin to formulate conclusions, which leads to the fourth and final step of interpreting results.

Step 4—Interpret the Results to Draw Conclusions

The digital divide in our nation really comes to light during the final step in the statistical problem-solving process. Once students have considered and analyzed the data, the focus shifts toward drawing conclusions about the disparities in accessible broadband connection. Students use their findings to try to answer their initial questions, exploring why different areas have different access. However, both Level B and Level C students may need support as they begin interpreting results and drawing conclusions.

Supporting Students

One way to support students with this thinking is for teachers to pose the questions, "What is the story the data is telling? Why does the variability in the data occur? How does the data answer your initial question?" Part of the interpretation process entails learning about and understanding possible factors for the variability found in the data. Students should spend time researching potential factors of the digital divide.

Poverty

Poverty is still an obstacle in closing the digital divide. In February of 2021, only 57% of surveyed U.S. adults making less than $30,000 annually reported having a connection to broadband at home (Pew Research Center, 2021). Broadband connectivity costs may be a factor in this, as a $60 per month broadband service would be unaffordable for 28% of households (Rogotzke et al., 2020). Many low-income households located in inner-city neighborhoods fall into this category, which may deter broadband internet providers from expanding their services to these areas. As students interpret their results, providing opportunities for them to dig deeper into rationale for the disparities, such as the aforementioned review of financial situations, will help them better understand the social aspects related to their discoveries from the data.

Social Justice Conversations

This is where teachers can incorporate social justice conversations. The FCC website gives students something to pull examples from, giving them access to this conversation. Students can share their findings with the class, along with specific examples that highlight disparities in accessible broadband connectivity. In our example, the significant gap in access between regions in Ohio can be directly tied to the issue of poverty. East Cleveland has the lowest number of broadband providers in the county. A simple Google search would tell you that this region happens to contain some of the highest levels of poverty in the Cleveland area. An example such as this can be a launching point for a social justice conversation about how poverty plays a role in the digital divide. It is important to note that students may bring their own backgrounds, experiences, and cultural perspectives into this conversation. Being responsive and providing space for students to share these qualities is crucial in sustaining a culture of access and equity in the classroom (NCTM, 2014).

Conclusion

The maps that students interact with on the FCC's website can highlight patterns of digital inequity by accentuating the glowing differences in broadband availability between residential areas. The mathematics classroom can foster meaningful exploration through the utilization of contextualized tasks. Centering statistical tasks in context provides students with a purpose for learning. These tasks can be enhanced by incorporating technological tools like the FCC's website. These tools empower students to interrogate real-world data through analysis in aims at exploring challenges facing society. NCTM recognizes technology as a principle of high-quality mathematics education in their Principles and Standards for School Mathematics (NCTM, 2000). Teachers can promote high-quality mathematics education by implementing technology that enables students to think critically about real-world issues. Teachers have an obligation to give students opportunities to critically analyze the world around them. If teachers do not expose students to real-world data, they bypass potential instances to make math meaningful. The mathematics classroom can be a place where students connect their learning with issues facing society, such as the aforementioned exploration of broadband disparity. Using real-world data as a context in statistics classes enhances the learning environment and gives purpose to the content being taught. Teachers can use the FCC's online interactive tool to give students practice with data analysis while simultaneously enlightening them to issues of digital equity. Students can engage in statistical analysis while simultaneously learning about the realities of this social justice issue. In doing so, teachers can prepare their students to use statistics in a critical and meaningful way.

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