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RESEARCH ARTICLE

Authenticity in a high school data science curriculum

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Abstract

Data is everywhere. Preparing students to navigate and succeed in a data-driven world is an increasingly important role for secondary education. Given its ubiquity, there is tremendous potential to situate data science in students' lived experiences. Toward this goal, this paper investigates ways to make data science learning experiences authentic. We explore how high school students perceive the authenticity of the datasets, tools, and learning activities they engage with in an interest-driven data science curriculum. Drawing from student reflections, survey responses, and in-depth analysis of final projects, we examine how the curriculum aligns with the four dimensions of authenticity proposed by Shaffer & Resnick (1999). The analysis reveals that students recognized the value of working with real datasets and tools, which enhanced their understanding of data science as a meaningful and applicable discipline. Students reported feeling like data scientists when completing learning activities that mirrored real-world tasks. This was particularly true for their final projects, which involved identifying and analyzing data to answer self-generated questions. The paper also presents design characteristics that foster authentic learning and discusses the practical implications for designing such curricula. The insights from this study contribute to the growing body of literature on authentic learning and underscore the importance of designing relevant and authentic curricula that prepare students for the data-rich world that awaits them beyond the classroom.

Keywords Authenticity · Data science · High school curriculum · Student perceptions

Introduction

Data drives our world and has an enormous impact on our lives. Therefore, it is crucial to be able to comprehend, interpret, and make informed decisions based on data (Gould, 2021). Data science (DS) provides the tools, methods, and practices needed to understand and analyze the vast amounts of data around us (Hazzan & Mike, 2023). To navigate this data-rich landscape effectively, students must develop conceptual understanding and technical skills to evaluate and manipulate data sources, perform analyses, and communicate findings (Bowler et al., 2017; LaMar & Boaler, 2021). Given the prevalence of data in

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students' lives, there is a significant opportunity to situate DS education in ways that draw on and relate to their everyday experiences (Weintrop & Israel-Fishelson, 2024). Educators can offer students relevant and empowering experiences by situating DS learning in authentic, real-world scenarios (Wilkerson & Polman, 2020). However, a significant hurdle is the lack of curricular resources that provide students with practical opportunities to work with real-world data (Wright et al., 2024). To address this challenge, there is a pressing need to create compelling, engaging, and authentic learning experiences that support the development of DS skills and practices.

Authentic learning involves engaging students in meaningful and relevant real-world tasks (Shaffer & Resnick, 1999). The goal of authentic learning is to situate learning experiences in ways that help students understand the value, usefulness, significance, and practicality of the knowledge to be acquired (Hagenkötter et al., 2024). This approach enhances learning by promoting a deep understanding of concepts and fosters motivational effects by increasing intrinsic motivation and engagement (Betz et al., 2016).

The primary objective of this study is to investigate the various ways in which authenticity can be designed into a high school DS curriculum and evaluate the results of doing so. Specifically, this study focuses on students' perceptions of authenticity as a crucial lens for understanding how curriculum design affects students' engagement in DS education. To guide our investigation, we pursued the following research questions:

1. *How do students perceive the different forms of authenticity integrated into a DS curriculum?*
2. *What characteristics of a DS curriculum contribute to it being perceived as authentic by high school students?*

This paper advances our understanding of the design of authentic learning experiences and contributes empirical evidence on their effectiveness in DS education. It offers insights into how students engage with and respond to real-time data exploration activities, computational analytic tools, and open-ended projects. Additionally, this study adds to the understanding of how authenticity can be operationalized in educational settings, providing a framework for future curriculum design. By focusing on students' perceptions, this study illuminates how they experience authenticity in a data science curriculum informed by real-world practices. Studying students' perceptions is fundamental to understanding how authentic learning experiences are perceived, interpreted, and valued. Gaining such insights can inform instructional design decisions that more closely align educational experiences with students' interests, values, and expectations.

Literature review

Authentic learning

Authentic learning has received significant attention over the past few decades as various researchers have defined and operationalized it. Newmann et al. (1996) focused on authentic pedagogy and proposed standards for assessment tasks and classroom instruction. For instance, they claimed that authentic tasks necessitate higher-order thinking skills, such as organizing, manipulating, synthesizing, generalizing, explaining, and evaluating complex information. Moreover, authentic instruction should incorporate disciplined inquiry and encourage students to connect to the world beyond the classroom through public problems or personal experiences. Shaffer and Resnick (1999) proposed a comprehensive view of authentic learning, defined as 'thick authenticity.' The four interconnected types of authenticity in their 'thick' definition are:

Personal authenticity: learning that is personally meaningful for the learner, emphasizing the importance of connecting educational experiences to students' interests, values, and goals

Real-world authenticity: learning that relates to the real world outside of school. It involves tasks that mirror those encountered in professional contexts, emphasizing the practical application of knowledge

Disciplinary authenticity: providing opportunities for learners to think in the modes of a particular discipline. It involves engaging learners in the kinds of thinking, practices, and methods used by professionals in the field

Authentic assessment: ensuring assessment reflects the learning process. It involves assessing learners' work in ways that align with real-world knowledge and skill applications

Building on these ideas, Herrington and Oliver (2000) proposed an instructional design framework for authentic learning environments, including design elements that characterize authentic learning. They emphasized the importance of complex, ill-defined real-world or professional tasks that require students to integrate knowledge from various disciplines. Betz et al. (2016) suggested a five-component model of authenticity in teaching and learning contexts, describing the characteristics and outcomes that authentic learning experiences may foster. Nachtigall et al. (2022), in their review of 50 studies on the effects of authentic learning settings on cognitive and motivational outcomes, analyzed study contexts, implemented design elements, and intentions of authenticity (i.e., the facets of authenticity). They consolidated the authenticity classifications from the literature into four intentions: (1) personally meaningful activities, (2) emulating professional work, (3) creating a community of practice, and (4) reflecting on everyday experiences. They found that only one study aimed to fulfill three of the four intentions of authenticity, and none combined all four. Additionally, only two reviewed studies evaluated learners' perceived authenticity (Nachtigall et al., 2022). The work presented below seeks to fill this gap in the literature.

Students' perceptions of authenticity have been shown to play a meaningful role in shaping how students engage with, interpret, and value educational experiences. Perceived authenticity can influence the motivational factors that drive engagement and sustained participation in learning, as students are more likely to invest cognitive and emotional effort when they find tasks relevant and meaningful to their lives (Hohrath et al., 2024; Svärd et al., 2024). Moreover, the perceived authenticity of learning materials and tasks is directly associated with students' disciplinary interest, professional relevance, and personal agency (Tran et al., 2025), suggesting that authenticity is not a fixed property of a task but is co-constructed through meaningful participation (Barab et al., 2000). Variation in student perceptions can stem from differences in interests, prior experiences, and disciplinary identities, which, in turn, shape whether students perceive the value and relevance of authentic tasks. This notion aligns with findings showing that students' subjective experiences and characteristics mediate their engagement and motivation across diverse educational contexts (Prananto et al., 2025).

Anker-Hansen and Andreé (2019) highlighted that the perception of authenticity can vary significantly between teachers and students. For example, educators may argue that innovation projects are authentic, yet they may struggle to inspire students who do not perceive these activities as relevant or connected to future technology-related endeavors or careers. Moreover, students can differ substantially in their perceptions of the authenticity of the same learning activity, underscoring that teachers cannot assume that a single design will resonate with all students. Rees Lewis et al. (2019) further support this by showing that even well-defined authentic projects can fail if they do not align with students' perceptions of what is authentic. This misalignment can diminish the genuine feeling of connection to real-world activities and negatively impact students' engagement and reactions to classroom activities. Therefore, understanding and incorporating students' views on authenticity is crucial for the success of authentic learning experiences.

The subjective nature of perceived authenticity presents both a challenge and an opportunity for instructional design. Teachers seeking to design authentic learning activities should consider how to accommodate diverse students' interests, backgrounds, and goals. Prior research indicates that responsive design strategies (e.g., including providing options for topic selection, integrating tools of varying complexity, and scaffolding tasks to align with students' zone of proximal development) may facilitate the needs of diverse students and maintain an appropriate balance between personal relevance and disciplinary depth (Herrington & Oliver, 2000; Strobel et al., 2013). These considerations can assist educators in fostering authentic, inclusive, and motivating learning experiences. However, given the variability and context-dependent nature of perceived authenticity, more empirical research is needed to understand how students' perceptions are shaped and how they influence learning experiences across diverse contexts.

Authenticity in data science education

Data science education is an emerging discipline at the intersection of computer science, statistics, mathematics, and various application domains (Mike et al., 2023; Rosenberg & Jones, 2024). It encompasses a broad range of activities aimed at understanding, analyzing, and interacting with data (Gould, 2021). It involves key practices such as data collection, processing, analysis, and visualizing, all of which are integral to drawing meaningful conclusions, making predictions, and informing decision-making processes (Schanzer et al., 2022). Given the significant role of DS education in preparing students to navigate our data-driven world, many educational initiatives and curricula have been developed for primary, secondary, and higher education (e.g., Janeja et al., 2024; Schanzer et al., 2022; Sukol, 2024; Walker et al., 2023).

Given DS's applied nature, DS curricula offer opportunities to engage students with authentic practices similar to those used by professionals to better understand the data surrounding them (Biehler et al., 2022). The tools that support DS practices are essential in enabling students to investigate data like data scientists (Lee et al., 2022). Various data analysis tools are used in K-12 education, including data-gathering tools, programming languages such as Python and R, and visual analysis tools such as CODAP and Tableau (Moon et al., 2023). Such tools shape students' learning experiences and support authentic DS practices (Pimentel et al., 2022; Pournaras, 2017). Therefore, DS curricula should provide rich computational activities supported by various data analysis tools (Lee & Wilkerson, 2018).

Just as the tools students use can impact perceptions of authenticity, so can the datasets students explore (Israel-Fishelson et al., 2024). By enabling students to manage and restructure real-world data in different formats using these tools, students are provided with authentic data experiences that connect data analysis practices with statistical skills (Grimshaw, 2015). Recent research conducted with teachers revealed that analyzing 'messy' or disorganized data and engaging with computational or programming tools during the analysis process is perceived as an authentic experience (Delaney & Lee, 2024). However, some instructors struggle to find authentic and valuable datasets within their domain (Kross & Guo, 2019). Hence, selecting engaging and relevant datasets related to students is highly important, as it can foster their agency and ownership (Lee et al., 2021).

Integrating the curriculum with students' interests and the real-world data they encounter can leverage the learning experience in DS. This approach can create more interactive and inclusive experiences (Brooks et al., 2021), improve students' connection with DS, foster curiosity, and boost their confidence (Lee et al., 2021; Wilkerson & Polman, 2020). Aligning educational activities with students' interests, perspectives, and prior experiences, and analyzing datasets in light of these, can enhance engagement and improve the likelihood of knowledge acquisition (Brooks et al., 2021).

There are different ways to design authentic learning experiences. One approach is to implement learning activities that emulate the work of professionals in a particular discipline (Nachtigall et al., 2022). In DS education, students might engage in projects where they collect, clean, analyze, and visualize real-world data, mirroring the tasks performed by data scientists. Such experiences can provide students with a context for their learning that is relevant and motivating, making abstract concepts more tangible and easier to grasp (Betz et al., 2016). However, authenticity should be evaluated by the students themselves. Considering students' perspectives is essential to ensuring the success of authentic learning experiences. This study follows this notion and examines how students perceive the authenticity of DS exploration activities.

Methodology

Research settings

The research took place in two computer science classes at a public charter high school in the Mid-Atlantic region of the United States during the 2023–24 academic year. In these classes, students used API Can Code, an interest-driven DS curriculum that introduces students to the computational foundations of DS through authentic, meaningful data exploration (Israel-Fishelson & Weintrop, 2025). The curriculum comprises three units, each containing six lessons (Fig. 1). The first unit focuses on the impact of data on learners' lives. Students explore and discuss the entities that collect their data and learn about data sources and ways to evaluate datasets. In the second unit, students practice foundational computational skills to programmatically retrieve, clean, process, and manipulate publicly available data from diverse Application Programming Interfaces (APIs). This is accomplished using EduBlocks, a block-based programming tool that introduces text-based programming languages, such as Python, in a user-friendly manner. Students learn how to use, modify, and create programs that retrieve and manipulate data from RapidAPI, an online platform with an extensive repository of publicly available APIs. For instance, students are introduced to the IMDb Top 100 Movies API and instructed to first execute a predefined program, then

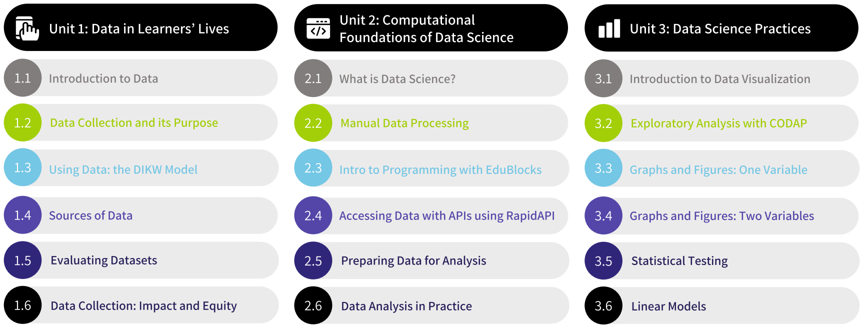

Fig. 1 Topics covered in each curricular unit

modify parts of it, and lastly develop a new program that queries the dataset based on their interests (e.g., retrieving the top movies in their preferred genre during a specific period). The third unit centers on DS practices, including data analysis and visualization to extract meaningful insights. Students use CODAP (Common Online Data Analysis Platform) to create and interpret various plots and perform statistical tests on the data (CODAP, 2022). By working with diverse datasets, including earthquakes, mammals, roller coasters, and housing data, students practice exploratory data analysis, identify misinformation and outliers, apply statistical techniques, and interpret results. The curriculum culminates with a final project that asks students to pose a question based on their interests, then identify and validate a data source from RapidAPI that can shed light on the question, gather and organize the identified data using EduBlocks, and then analyze and visualize it using CODAP to answer the stated research question. The students present their findings to their peers using structured slides and submit their EduBlocks programs, presentations, and scripts.

To support students' learning process, they are provided with exemplar programs, ready-to-use slides for each lesson, video tutorials, a glossary, and exit tickets. Additionally, a list of free-to-use APIs, categorized by topic and validated by the research team and the teacher, is provided. Teachers are provided with a structured rubric to help them assess the submitted materials. The computer science teacher who taught the curriculum underwent weekly professional training with a team of two researchers. During these sessions, they jointly reviewed the curricular materials, including structured lesson plans, presentations, and assignments. Each curricular lesson lasted 90 min and took place in the same classroom.

Interest development theory, which emphasizes that students thrive when they explore and interact with materials that interest them (Michaelis & Weintrop, 2022; Renninger & Hidi, 2015), informed two main aspects of the curriculum. First, across the three units, the API Can Code curriculum incorporates data exploration activities using datasets on themes such as music, animals, sports, and video games, which align with students' interests as identified in our earlier participatory design research among high school students (Israel-Fishelson & Weintrop, 2025). These activities were intended to support situational interest and establish a meaningful entry point into data science concepts and practices. Secondly, students are given increasing autonomy as the curriculum progresses, culminating in an open-ended final project in which they can select or bring in their own datasets, pose personally meaningful questions, and conduct comprehensive investigations that align with their interests. This structure was designed to support the transition from situational to emerging individual interest by allowing students to explore issues they care about using real-world practices and datasets.

Participants

The study involved 25 12th-grade students (average age of 17.2) from the two computer science classes, including 13 females and 12 males. Out of 25 students, 22 identified themselves as Black/African American, one identified as American Indian or Alaska Native, and two preferred not to specify. Additionally, 22 students had previously taken a computer science course (e.g., AP Computer Science Principles and Object-Oriented in Python). The authors obtained approval from their institution's Institutional Review Board, and all students, and when necessary, parents/guardians, consented to participate in the study.

Data collection

To evaluate the authenticity of the DS curriculum, we employed a mixed-methods approach, collecting both qualitative and quantitative data from multiple sources. These sources included classroom observations, video and audio recordings, pre- and post-surveys, semi-structured interviews, and student-generated materials. Below is a detailed description of these methods.

- **Classroom observations**: The first author conducted classroom observations during the lessons and took field notes, attending to student engagement, interactions with the materials, and computational tool use. In addition, the author video-recorded the lessons for later analysis.
- **Surveys**: Pre- and post-curriculum surveys were administered to evaluate students' interest, motivation, and perceived curriculum relevance. The surveys featured 5-point Likert-scale items and open-ended questions that enabled students to elaborate on their experiences and attitudes toward DS.
- **Semi-structured interviews**: After each instructional unit was completed, the first author conducted semi-structured interviews with a sample of five students. These interviews provide in-depth insights into students' experiences and perceptions of the curriculum and its instructional materials. A total of 15 interviews with 13 different students were conducted.
- **Student-generated materials**: All materials generated during the lessons, including students' worksheets, programs, and final project presentations, were collected for analysis. These materials provided additional insight into students' engagement with the curriculum and their ability to apply DS concepts to authentic contexts.

Data analysis

To analyze authenticity, we applied Shaffer and Resnick's (1999) framework, which consists of four dimensions: personal authenticity, real-world authenticity, disciplinary authenticity, and authentic assessment. The analysis process involved two sequential coding phases:

1. **Relevancy coding:** Two researchers independently reviewed **350 interview segments** and determined whether each segment was related to authenticity (Yes/No). They identified 108 related segments. Inter-rater reliability was calculated using Cohen's Kappa (Cohen, 1960), yielding a satisfactory coefficient of 0.79, indicating substantial agreement between coders. Discrepancies were discussed and resolved through consensus before proceeding to the next analysis phase.
2. **Dimension coding:** After determining the relevance of each segment to the focal construct of authenticity, the researchers conducted a second round of coding to independently categorize each relevant segment according to the four authenticity dimensions. Importantly, segments could be assigned to one or more dimensions, as instances of authenticity were not always mutually exclusive, such as when students worked with a dataset that aligned with their personal interests and reflected legitimate real-world data science task. Each segment was coded based on whether it reflected: (1) Personal Authenticity (alignment with students' interests, values, and goals); (2) Real-world Authenticity (connections to real-world applications and contexts outside of school); (3) Disciplinary Authenticity (engagement in professional DS practices); or (4) Authentic Assessment (assessment methods that mirror real-world evaluation criteria). Cohen's Kappa yielded a satisfactory coefficient of 0.89, indicating strong agreement between coders. Similar to the first phase, all discrepancies were discussed and resolved.

The final coded dataset was examined for recurring patterns and themes, allowing us to assess how students perceived the authenticity of the curriculum. Additionally, we conducted an additional thematic analysis of survey responses and final project materials. Survey responses, particularly those that capture students' attitudes and reactions toward the curriculum, were analyzed using open coding to identify references to authenticity across the four dimensions. Final projects were coded under the authentic assessment dimension as they reflected students' engagement with real-world DS practices, their ability to conduct independent investigation, and their application of learned concepts to structured projects. By analyzing these additional data sources separately, we ensured that student voices were captured across different modes of engagement, providing a more comprehensive understanding of how authenticity was experienced throughout the curriculum.

Findings

We structure our Findings section using our two guiding research questions, first answering our questions about students' perceived authenticity and then discussing design features that contributed to those perceptions.

Students' perceived authenticity

To operationalize authenticity in this analysis and answer our first research question, we use the lens of Shaffer and Resnick's (1999) 'Thick Authenticity' framework, which has four dimensions: Personal Authenticity, Real-world Authenticity, Disciplinary Authenticity, and Authentic Assessment.

Personal authenticity

This first dimension of authenticity reflects the alignment of learning experiences with students' personal interests, goals, and identities. As Shaffer and Resnick (1999) asserted, *"educational significance of an activity must be judged—at least in part—by its significance to the learner"* (p. 199). The curriculum's interest-driven design and use of real-time data exploration activities were intended to make learning personally meaningful for students. Our preliminary research (Israel-Fishelson & Weintrop, 2025) revealed that high school students were highly interested in topics such as music, video games, movies, sports, and animals. These findings directly informed the selection of datasets and themes in those data exploration activities. For example, students analyzed data on trending music using the Billboard Hot 100 Songs API and explored statistics about NBA players and teams. They also investigated data related to animals, earthquakes, house prices, and "food deserts" around their community. These topics were selected as students expressed interest in them during participatory design sessions conducted in an earlier phase of the project (Israel-Fishelson & Weintrop, 2025).

The analysis of the interviews revealed that students found the use of interest-driven data exploration activities engaging and aligned with their interests, and thus, personally authentic. For instance, the incorporation of entertainment-related datasets like the Billboard Hot 100 songs and IMDb Top 100 Movies was particularly well received. One student commented, *"I think the use of music was really good because a lot of kids listen to music."* Another student noted, *"Honestly, I found it really interesting because I make music myself. I found it to be really good information for me to take in personally. So, I really liked that part of the class."* A third student added, *"I watch movies a lot. I think those two* [datasets] *were very good topics to pick."* Additionally, one student pointed out his positive experience with the NBA API, where he explored the achievements of different teams: *"It was really fun just trying to figure it out. I don't typically watch the NBA like that. So, it was interesting for me to find out the losses and wins."*

However, not all students found the curriculum personally relevant. Our analysis also revealed instances where students expressed neutrality or a lack of a deep personal connection. For example, one student noted, *"I mean, the curriculum is interesting, but I wouldn't say it is my passion or anything."* Another student remarked, *"I wouldn't say the class is particularly relevant for me; maybe outside of school, but I wouldn't mind learning more about it."* This response suggests that even students who were not initially interested in certain topics found value in the exploration process and recognized the relevance of DS beyond the classroom. Additionally, another student highlighted the role of motivation in engagement: *"I mean, it was alright…It is more about wanting to do it. As you have seen, some students in the class just don't really engage. If they don't feel like it's relevant to them, they're not going to do it."*

Students further expressed a desire for more personalized content that resonates with their lived experiences. As one student suggested, *"Maybe add something* [datasets] *that connects a little bit more to us, like video games more often, or cultural stuff, just for fun."* Another added: *"Ask students what they want to pursue a career in and try to find datasets that align with it. So have interest. People would be more interested and want to ask more questions if it's something they're interested in. For example, if we did datasets related to psychology, it would probably grab my attention more than basketball."* This feedback highlights the importance of designing DS experiences that enable individual, interest-driven inquiry, as it promotes deeper engagement and investment in the learning process.

Perceived Personal Authenticity was also evident in the interviews regarding the final projects. One student remarked, *"I chose the dog breed API because I love dogs. I have two at home. I just wanted to learn more about different breeds than I have because maybe I will want some in the future."* The freedom to choose their own topic allowed this student to pursue a personally meaningful subject, showing how their love for dogs and curiosity about different breeds drive their engagement in the final project. Another student's project on video games also illustrates Personal Authenticity: *"The API I chose was in the video game section, as I really like video games."* By connecting the project to a personal passion, the student could engage more deeply with the DS practices involved, enhancing the sense of relevance and motivation. In doing so, the curriculum became more personally authentic as it was more meaningful to them.

Real-world authenticity

The second dimension of authenticity attends to the link between the learning experience and its real-world applications. Shaffer and Resnick (1999) state authentic materials should *"reflect or recreate some aspect of the world outside of school…for example, authentic activities might ask students to investigate a 'real' problem"* (p. 198). Our analysis revealed that having students use live and updated datasets from various domains helped promote real-world authenticity by helping them see the broader relevance of DS beyond the classroom, as one student said: *"The topics were real situations. We used a lot of real data from around the world. It was not made up."* Another student added, *"A lot of the stuff that we do in that class we apply to real life. Like we did with the bus stops and metro stations in the city and stuff like that."* These statements underscore how integrating real-world data, such as earthquakes, roller coasters, transportation, and grocery store locations, made the learning experience more tangible and grounded in practical applications, allowing students to engage meaningfully with the curriculum.

Another student added, *"The class was relevant, especially with how he [the teacher] taught it, i.e., describing things and explaining that the whole world relates to data science."* This statement highlights the importance of the instructor in contextualizing the curricular material to help students grasp the broad applicability of DS. The curriculum not only covered academic content but also emphasized how DS plays a role in everyday life and across various professional fields. For example, during the lessons, the students were encouraged to consider how an annual dataset from Starbucks could help the company increase its profits, what useful insights NBA coaches could derive from data on NBA teams, and who the stakeholders interested in patients' medical information might be.

Familiar, culturally relevant datasets further solidified the curriculum's Real-world Authenticity. For example, the Top 100 Movies and Billboard Hot 100 Songs datasets, which students often cited as aligning with their personal interests, were also noted for their contemporary nature, reflecting real-world phenomena they encounter in their daily lives. As one student reflected, *"We are doing things like the Top 100 movies; it is real stuff related to society. It is like we are doing real work, but not like on a serious one like global warming."* While this student recognized that tasks related to pop culture might not carry the same perceived societal importance as global issues, they still acknowledged the realism of working with real-world data. Nonetheless, these reflections show how the curriculum successfully demonstrated that even pop culture and entertainment data could be analyzed through the lens of real-world DS practices.

Beyond identifying the real-world connections of the datasets, students began to recognize how the practices they were learning could be applied to their future careers. These aspects align with Shaffer and Resnick's (1999) concept of Real-world Authenticity, which emphasizes the importance of learning activities having value or meaning beyond the classroom walls. For example, a student aspiring to a career in cybersecurity stated that he would use the practices learned in class *"mostly in my career,"* indicating that he views the skills from class as transferable to his professional aspirations. Another student emphasized, *"Honestly, I think it depends on your career path. But I think it's always good to have on your resume, and it's a useful skill to acquire."* Another student reflected, *"I could see how it will become useful. Even though it is not particularly hand-in-hand with what I'm doing, I'm going to handle a lot of data; it helps me learn how to analyze the data."* Another student echoed this sentiment: "*It felt like what we were doing could actually be used outside of school."* These responses illustrate how students saw clear connections between the learning activities and their professional futures.

Students' observations about the data analysis process further highlighted its real-world relevance: *"The way that it is set up and the way that we do the activities, it does feel like we are doing real work."* This indicates that the curriculum structure, along with specific dataset topics, helped students relate their learning experiences to professional tasks. This highlights the practical application of their skills and the Real-world Authenticity of the learning experience. As one student summarized, *"The course really gave me insight into how important data is,"* capturing the essence of how the curriculum helped students realize the broader significance of DS skills in both personal and professional contexts.

Disciplinary authenticity

The third dimension of authenticity, outlined by Shaffer and Resnick (1999), involves aligning learning activities with the types of thinking, practices, and tools used by professionals in the field. Indeed, the API Can Code curriculum was designed to introduce students to the foundational practices used by DS professionals. Students were engaged in the complete DS workflow, from collecting and manipulating data to analyzing, visualizing, and presenting the results. They used tools like RapidAPI, EduBlocks, and CODAP, which, while not commonly used by professional data scientists, support the same set of fundamental practices.

Student responses to the post-survey prompt *"When in particular did you feel like a data scientist in this curriculum?"* shed light on when they felt most connected to professional practices. Seven students mentioned the final project as their peak experience. One student stated, *"I mainly felt like a data scientist when working on the final project."* Four others shared similar sentiments during their interviews. As noted by one of these students: *"I feel like a scientist in this [final] project we are currently working on because of its requirements and how I used the data."* The opportunity to formulate questions, apply skills, and work with contemporary and relevant datasets during the final project likely contributed to their sense of Disciplinary Authenticity. As one student reflected, *"We get to test our own skills,"* suggesting that the final project plays a role in building their confidence to investigate and analyze real data.

Five students mentioned the class exercises, like the data exploration activities, as moments when they felt like data scientists, indicating that even structured, teacher-guided activities offered opportunities for disciplinary engagement. During the post-unit 2 interview, one student gave a concrete example reflecting on these activities, *"I felt like a real* *data scientist when working on the COVID case and the project right now."* Another student added, *"It seems like we are doing something that real data scientists do because data scientists look at that stuff."* Such data exploration activities allowed students to apply DS concepts and employ fundamental DS practices on smaller, focused tasks, emphasizing the alignment between learning activities and authentic DS.

Various tools also played a crucial role in reinforcing this Disciplinary Authenticity. Six students highlighted the work with the tool they used throughout the curriculum as a key moment when they felt like data scientists. The three focal tools in the curriculum, RapidAPI, EduBlocks, and CODAP, provided students with hands-on experiences that mirrored the practices performed by professional data scientists. One student noted, *"It felt like real data science. It was really science-y, you know, technology-based."* Another student noted he felt that when *"programming in Python and also doing the statistics."*

Overall, students reported a positive experience with these tools. However, alongside these successes, several students described initial challenges. For example, one student shared, *"At first, I was a little confused, but then it got easy because it is just like Scratch, but a little more advanced,"* referring to their use of EduBlocks. Another student commented, *"It wasn't the material that was hard. I didn't really know how to use the site,"* referring to difficulties navigating RapidAPI and retrieving data. Similarly, a student noted, *"The only thing that confused me was trying to understand what exactly my errors were,"* pointing to the challenges of debugging their program. These challenges reflect the real-world experience of novice programmers and data scientists, for whom debugging and navigating new tools are essential parts of professional practice. As one student summed up their experience, *"RapidAPI is new to me, so it's a little bit hard. It's like learning over time, so this is getting easier and easier."* Such reflections suggest that, while there was a learning curve, students developed technical skills over time, mirroring the incremental learning process seen in authentic professional settings.

While some students made connections between the tools, concepts, and practices learned in class with the DS profession, others recognized they were still beginning their DS journey. As one student put it, *"I am not feeling like a data scientist because I know that they are doing a lot more than we are doing. We are just scratching the surface,"* indicating that while they engaged with the discipline, they were aware of the limitations of their learning experience compared to the full scope of professional work. While this statement reflects the gap between what students are doing and what professional data scientists do, it does highlight the connection between classroom practices and the real world. Moreover, such responses emphasize that future iterations of the curriculum should enhance this sense of authenticity by offering more advanced tasks and professional-level tools.

Assessment authenticity

The final dimension of authenticity outlined by Shaffer and Resnick (1999) focuses on evaluating students' work through tasks that genuinely reflect the knowledge and skills necessary for success in the real world. The final project was a key assessment component, requiring students to apply the knowledge, practices, and skills they had gained throughout the curriculum. The project had students pose a driving question, write programs to gather, manipulate, and analyze real-world data, create visualizations, and present their findings to peers. Students had the freedom to explore topics that were meaningful to them, making the project a personalized and relevant experience. This approach ensured that assessment was not just about testing knowledge but also about evaluating students' ability to apply their skills in practical scenarios. Students' investigations involved iterating on initial questions, refining them based on available data, and developing evidence-based conclusions—demonstrating authentic DS problem-solving.

As part of the final project submission, students had to complete a script. This script guided students in articulating the rationale and evaluation criteria for selecting their dataset, evaluating characteristics of the retrieved data such as its accuracy, reliability, completeness, and value, reflecting on their investigation and decision-making processes, and self-reporting their confidence in their findings. These scripts served as formative assessment tools, allowing students to self-assess their understanding and analytical choices while engaging deeply with an authentic task.

One student who chose to investigate dog breeds posed descriptive and predictive research questions such as: *"What is the largest size/length a dog can grow to be?"*, and *"How long can I expect my dog to live?"* In her reflection, she detailed her data analysis process: *"My data is not as diverse, but it has different topics and different varieties of dogs. Going over this data, there are a lot of interesting facts you can pull from it. I have a lot of data that'll answer my questions. There is numerical data and qualitative data. The numerical data mostly represents the max life span of the dog, the average weight, and height. The qualitative data represents the breed's name and or type and such things like that."* This reflection highlights the student's clear understanding of the data structure and ability to distinguish between data types in complex datasets, a key competency in DS. Collectively, it highlights how the assessment is authentic in terms of asking students to engage in real data science practices. Asking students to evaluate datasets and determine if their questions can be answered emphasizes the authentic assessment, as students are not provided with a pre-screened dataset that will lead them all to the same premeditated answer.

Another student, working with NFL data, investigated the question, *"What team had the most successful season based on overall performance?"*. He detailed how the assessment enabled him to answer the research question systematically by analyzing various team statistics: "*The data I collected helped me primarily figure out my answer to the question. The specific data I collected was from the official NFL 2023–24 season statistics. I used how many wins each team won, how many losses each team took, and whether or not a team made the playoffs. Ultimately, the final dividing factor is which team won the Super Bowl. Each dataset represents its own category, which gets me steps closer to getting answers to my question. The data is reliable and valuable."* This response highlights how the curriculum's authentic assessment facilitated structured inquiry with real-world data, helping students build confidence in drawing conclusions. Moreover, it sheds light on the student's understanding of critical concepts, such as data reliability and significance. The student's reflection that *"My project was not that hard to do; in fact, I found enjoyment in doing the project"* suggests the assessment succeeded in engaging students with complex data tasks by aligning the projects with their interests, thus enhancing skills development and motivation.

In another reflection, a student who explored housing data using the Zillow API illustrated how multiple data visualizations helped her answer her question, saying: *"I created dot graphs to visualize my answers, and they helped me come to my conclusion of what is the most popular home type in Houston."* The student also described how each visualization answered different aspects of her research question, such as home popularity by type and location: "*The first graph displays which home type is the most popular for sale in Houston. The second graph shows the number of bathrooms in each home type and which home type seems to have the most bathrooms. The third graph shows which home type* *is popular in different zip codes."* The student's confidence in her analysis is evident in the final reflection: *"This dataset is valuable and meaningful to Houston home buyers. This could be used as a guide to finding the perfect house. I am confident in my answer because I feel like I got good data."* This reflection shows how the assessment fostered not only technical skills, such as data visualization, but also the ability to relate data analysis to real-world applications, making the learning experience feel relevant and valuable. Furthermore, these reflections demonstrate authentic assessment design. The final project encouraged students to explore personally meaningful topics, analyze real-world datasets, and present their findings. This not only helped them apply technical skills but also allowed for a deeper engagement with the assessment activities.

While our analysis focuses on students' reflections as evidence of authentic assessment, it is important to note that these reflections complemented the teacher's summative evaluation. Students' final projects were assessed using a rubric aligned with core data science practices, including data source evaluation, data cleaning, data manipulation, visualization, interpretation, and communication. Although teacher evaluation data were not analyzed in this study, the assessment structure ensured that students were evaluated on the application of real-world data practices in context. For a more comprehensive account of assessment practices from an instructional perspective, we refer readers to the publicly available resources under the API Can Code curriculum's website.

Characteristics that foster authentic learning

Our second research question seeks to understand the characteristics of a DS curriculum that lend it authenticity in the eyes of the learner. The curriculum design emphasized several key characteristics that together contributed to the sense of authentic learning by the students documented above. The curriculum's flexibility boosted Personal Authenticity by enabling students to pursue data exploration activities and projects that resonated with their diverse interests. Interview responses show that students appreciated the curriculum's structure and the variety of topics and activities. One student noted, *"I like that you incorporated different activities. I think it got a lot of people engaged in the lessons."* Another student reflected on their learning experience, stating, *"I really do like how we switch up* [the topics]. *I like the different materials that we use. We don't do music every day or movies every day."* This variability helped maintain engagement and broaden students' perspectives on different applications of DS. Moreover, students had the autonomy to formulate research questions and choose datasets that intrigued them, fostering greater engagement and commitment to the learning process. This characteristic of student-led content selection is consistent with research showing that interest-driven learning promotes students' motivation and persistence in their studies (Michaelis & Weintrop, 2022; Renninger & Hidi, 2015). Such alignment underscores the value of tying DS instruction to students' interests, fostering dynamic, engaging, and equitable learning experiences (Brooks et al., 2021). Moreover, allowing students to choose their datasets makes DS more personalized and meaningful, helping them grasp the importance and relevance of the field and enhancing their connection to it (Lee et al., 2021; Wilkerson & Polman, 2020).

The curriculum achieved Real-World Authenticity by allowing students to work with live, real-time datasets from domains relevant to their lives and interests. Students acknowledged the value and relevance of the APIs and datasets they worked with, whether analyzing top movies, music trends, sports statistics, or housing prices. This characteristic of grounding learning activities in real-world data enabled students to connect the curriculum to practical and meaningful applications, supporting research indicating that students are more likely to engage with material when they perceive its real-world relevance (Anker-Hansen & Andreé, 2019). Moreover, students acknowledged the value of the studied practices, their transferability, and their applicability to future careers.

The curriculum demonstrated Disciplinary Authenticity by structuring the lessons around the core practices of DS. Students engaged in fundamental DS practices, including data collection, evaluation, cleaning, manipulation, analysis, and visualization (Sukol, 2024). The practices and learning trajectories are grounded in the existing DS education literature (IDSSP Curriculum Team, 2019; Lee & Delaney, 2022). Moreover, they were tasked with formulating their research questions, deriving conclusions from data analysis, and communicating results. Students were provided with hands-on experiences and worked with tools such as RapidAPI, EduBlocks, and CODAP to apply the core DS practices they had learned. This approach supports research indicating that mirroring professional practices helps students internalize the methods and mindset of professionals (Kafai & Burke, 2014; Lave & Wenger, 1991).

Finally, Authentic Assessment was embedded in the curriculum through a culminating project that guided students through the DS cycle (IDSSP Curriculum Team, 2019). Students formulated questions based on their interests, gathered, evaluated, and analyzed relevant datasets, created visualizations, and presented their findings to peers, mirroring professional DS practices. They also completed a structured script reflecting their learning trajectories and were assessed using a rubric aligned with core DS practices. This assessment evaluated both technical proficiency and the ability to apply these skills in practical, real-world contexts. As Gulikers et al. (2004) highlighted, authentic assessments are essential for ensuring that students can transfer their learning to new and relevant contexts, further solidifying the relevance of the curriculum.

Discussion

Authentic learning experiences are critical to fostering meaningful, long-lasting educational outcomes. Such experiences enable students to develop problem-solving skills, critical thinking, and the ability to apply knowledge across diverse contexts—key competencies needed in today's complex and data-driven world (Reilly & Reeves, 2024). Authentic learning is pivotal in DS education, where students must connect abstract concepts with practical, real-world applications. Authentic learning offers students opportunities to work with real data and engage in practices that simulate those of professional data scientists. Such an approach not only enhances students' technical abilities but also enables them to recognize the broader relevance and applicability of what they are learning in everyday life and in their future careers (Philip & Sengupta, 2021).

Data science education as a discipline for authentic learning experiences

As a field, DS is particularly well-suited for fostering authentic learning experiences due to its inherent flexibility and alignment with real-world applications. The availability of diverse datasets allows students to explore topics that align with their interests, fostering a personal connection that enhances engagement. Moreover, DS practices, such as data collection, analysis, and visualization, are naturally student-appropriate adaptations of professional work, offering students an accessible entry point into the discipline. Authentic assessments, such as projects in which students investigate questions using real data, align seamlessly with DS education goals, enabling students to experience the complete DS cycle while demonstrating their understanding. By leveraging dimensions of authenticity—through choice in datasets, tools that balance accessibility and professional relevance, and activities mirroring real-world practices—curriculum designers can create educational experiences that resonate deeply with students, preparing them for real-world applications and instilling a sense of disciplinary identity.

Tensions among dimensions of authenticity

Designing an authentic DS curriculum involves navigating the inherent tensions among the four dimensions of authenticity. Balancing these dimensions can be challenging, as focusing on one form of authenticity may impact another. For example, designing data exploration activities that enable students to work with data closely aligned with their interests (e.g., datasets on social media or music trends) can enhance engagement and increase levels of Personal Authenticity. However, it may limit the opportunities to engage students with Disciplinary Authenticity, as the data may not reflect the complexity required to develop the analytical and technical skills needed in the field. Conversely, prioritizing Disciplinary Authenticity by introducing professional tools and practices may inadvertently reduce students' sense of personal connection and self-efficacy if the tools are too complex or the datasets are distant from their interests.

This tension emerged in our study when students who were highly motivated by the topic of their data still expressed frustration with debugging their EduBlocks programs or navigating RapidAPI. These instances underscore the importance of thoughtfully designed scaffolding that promotes students' technical growth without compromising their intrinsic motivation. One way to tackle this is to offer varying levels of complexity across curricular assignments or to provide a curated list of APIs aligned with different areas of interest. Structured scaffolds, such as guided questions, tool walkthroughs, and sample programs, can support students in approaching more complex and rigorous disciplinary practices while still situating them in their lives.

Similarly, the tension between Real-world and Personal Authenticity can emerge when connecting the curriculum to societal issues. For example, while real-world datasets on topics such as earthquakes and public health can provide rich opportunities for disciplinary engagement, they may lack the immediate relevance or personal connection that enhances Personal Authenticity. Curriculum designers can mitigate this issue by linking societal datasets to students' local or personal experiences. An example from our work would be exploring COVID-19 data or food deserts within their region or community.

Another area of tension arises in aligning Authentic Assessment with Disciplinary Authenticity. Authentic Assessments require students to apply disciplinary DS practices in meaningful contexts. However, creating assessments that enable this type of application may be challenging. In the API Can Code curriculum, the final project is designed to evaluate the students' capabilities in data analysis and visualization, as well as their ability to present insights on a topic of their choosing. This assessment method may uncover varying levels of technical skills based on the complexity of the data selected by each student. Some students may choose a more straightforward dataset that makes it easier to demonstrate the studied practices, while others may choose complex, multidimensional datasets that challenge their ability to present coherent findings. Balancing these diverse skill levels in the assessment criteria can help ensure that the assessment is in line with disciplinary objectives without compromising the authenticity of the experience.

To address this conundrum, educators might consider scaffolding activities through pedagogical frameworks. For example, the API Can Code curriculum uses the Use → Modify → Create strategy, which provides scaffolded exposure to the practices as students build confidence and is an effective strategy for navigating such tensions (Franklin et al., 2020). Rather than having students work exclusively with datasets they choose, educators can introduce data that broadly aligns with students' interests and allow them to formulate and explore their research questions within this structured context. For example, educators could provide students with comprehensive datasets in several areas of interest, enabling them to apply disciplinary practices while selecting a specific artist or genre that personally resonates with them.

Challenges in designing authentic learning experiences

Developing authentic learning experiences broadly and, specifically, in DS, presents several design and instructional challenges. One primary difficulty lies in creating activities that are personally meaningful to a diverse student population. Although the curriculum integrated datasets aligned with students' interests, as evidenced by prior research with a similar population, some students struggled to engage with them. Moreover, even when students had the autonomy to choose their own datasets, some struggled to identify genuinely engaging topics. Thus, creating an interest-driven curriculum that enables students to explore datasets or topics relevant to their interests is often time-consuming, requiring careful planning and adaptation. APIs are particularly useful in this regard, as they offer a vast array of datasets that educators can draw on to align the materials and activities with students' interests. However, keeping the curricular materials up-to-date and aligned with current professional practices and shifting students' interests is demanding.

Developing and maintaining authentic curricula for technology-related fields can be challenging, given the rapidly changing landscape of computational tools. For example, tools such as RapidAPI and EduBlocks were selected for this curriculum because they provide students with real-world data access and programming in accessible formats. EduBlocks uses a block-based interface to introduce Python, and RapidAPI simplifies access to external datasets through a uniform syntax. However, these tools are relatively new, and it is unclear how long they will remain relevant authentic with respect to disciplinary practices. The volatility of third-party platforms and tools raises questions about the long-term sustainability of authentic curricula. Moreover, while real-world tools can facilitate meaningful learning, they can also be overwhelming without adequate guidance. For example, some students in this study reported challenges in handling errors in the code.

The curriculum attempted to address this through structured instruction, video tutorials, and student handouts, but individual differences in experience and confidence shaped students' perceptions of the activities. This highlights that authenticity is not experienced uniformly. What one student finds meaningful and relevant, another may find difficult or disconnected. Therefore, designing a curriculum that supports all dimensions of authenticity, for all students, requires a balance between student choice and structured support.

Practical implications

This study provides a concrete example of a DS curriculum that incorporates multiple dimensions of authenticity to foster deep and meaningful engagement among high school students. Further, it identifies curriculum characteristics that contribute to students' perceptions of the authenticity of the learning experiences. In providing this example, we demonstrate various strategies that can be employed to bring various dimensions of authenticity into the classroom. This includes consideration of students' interests, incorporating tools and practices aligned to professional practice, and linking classroom content with the world beyond. As such, modifications to attend to authenticity must be scaffolded to ensure that students have the necessary support to manage the complexity of the tools and datasets.

Platforms like EduBlocks and RapidAPI, while designed to simulate professional workflows, can be challenging for both students and educators. However, these platforms were chosen intentionally for their accessibility. EduBlocks, for example, uses a block-based Python interface that eases the entry point for novices by reducing syntax errors and promoting visual learning. Similarly, RapidAPI simplifies working with APIs by providing a consistent interface and syntax across many datasets, helping students focus on retrieving data rather than navigating different request formats. Still, successful integration of these tools may require teacher training, including exposure to API documentation, error handling, and basic debugging strategies. Providing pre-built code examples can help both students and teachers confidently overcome these hurdles. To support these needs, the API Can Code curriculum includes a professional development program that familiarizes teachers with the tools and pedagogical principles. In addition, various scaffolds, including video tutorials, student-facing guides, and code examples, are freely available to help both teachers and students troubleshoot common issues and build confidence.

This study also suggests that while some students are motivated by autonomy as a mechanism for Personal Authenticity, others may need more explicit guidance to find relevance or manage data effectively. Teachers and curriculum developers should consider balancing student choice and structured guidance, helping students navigate complex datasets while focusing on relevant, real-world questions. Tailoring instruction to address varying levels of comfort with the learning activities is crucial for making the curriculum accessible to all learners. Moreover, allowing students to choose diverse topics inherently introduces variability in project complexity, which can challenge consistent grading. To address this, curriculum designers may consider creating adaptable rubrics focused on core data science competencies (e.g., data analysis, data visualization) that allow for topic variation. In the present study, this balance was supported by such a rubric and structured project components, such as the final project script and peer presentations, which ensured that, regardless of topic, students demonstrated key skills and reflective thinking.

Limitations and future research

While this study demonstrates what authentic learning can look like in a high school DS classroom, several limitations should be considered. First, the data for this manuscript were collected in a single high school setting, involving 25 students from one school community. Most students had some coding experience prior to being introduced to the data science curriculum, which may have contributed to their relatively high level of comfort with its technical aspects. Moreover, the teacher implementing the curriculum had a strong background in data science and programming, which likely influenced the success of supporting students. These contextual factors may not be present in other school settings, particularly those with fewer technical resources, less teacher support, or lower baseline familiarity with programming. Thus, outcomes may differ across schools serving populations with different educational backgrounds and needs. Additionally, while the curriculum incorporated real-world tools and datasets, there were constraints in terms of time and the depth of analysis possible within the framework of a high school course. These factors limited the extent to which students could fully immerse themselves in professional-level DS practices. Future research could explore how authentic learning experiences can be adapted and scaled to different educational settings and how the findings presented in this work generalize to larger populations, different geographic regions, and varied curricula and tools.

Moreover, although the curriculum was designed as an introductory course in data science, aiming to build foundational skills rather than professional-level mastery, the use of real-world tools and datasets did pose challenges within the constraints of a high school schedule. Instructional time, course pacing, and students' varying skill levels imposed natural limits on the depth of analysis and the complexity of tasks students could complete. Future research should explore how such authentic learning experiences can be adapted and scaled to suit a wider variety of educational contexts.

Another limitation is that not all students were comfortable or willing to share their reflections during the study. Some students may have felt discomfort voicing their thoughts, which could introduce a degree of response bias into the qualitative data collected. Given this limitation, future research should supplement qualitative reflections with more structured, validated questionnaires to assess students' perceived authenticity of the learning experience. Such an instrument could systematically verify the perceived authenticity of the curriculum and complement the insights provided by the open-ended reflections. This combined approach would create a more comprehensive understanding of how authentic learning experiences are perceived and could help refine future implementations to address a broader range of student needs.

Finally, the study's focus on students' perceptions presents its own limitations. While perceptions are essential for understanding student engagement and the experience of authenticity, they do not fully capture learning outcomes or long-term impacts of the curriculum. Future research should build on these findings by pairing perceptual data with assessments of learning outcomes to offer a more comprehensive understanding of how authenticity influences students' skill development and learning trajectories.

Conclusions

This study presents the design of a DS curriculum that integrates multiple dimensions of authenticity and examines how students perceive and respond to them. The curriculum's real-world connections, disciplinary alignment, personal relevance, and genuine assessment methods contributed to students' engagement and their sense of working on interesting professional tasks. Students could connect DS to real-world issues, employ tools and practices used by professionals, and work on personally meaningful projects that bridge theoretical concepts and practical applications. Integrating these authentic experiences fostered a sense of ownership and relevance, ultimately helping students prepare for the data-rich world that awaits them.

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Declarations

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Consent to participate Written informed consent was given by all participants and, when necessary, by their parents/guardians.

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