

Research Article

Designing and implementing a data science module for gifted middle school students

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This study examines how a data science learning module can be added to a middle school programming curriculum for gifted students. Six gifted students participated in a seven-week program focused on data science using Python programming. We conducted semi-structured interviews with the students' information technology teacher before and after the implementation. The insights from these interviews guided our course design. Next, we implemented a seven-week data science teaching module, in which students used Python to analyze real digital game data. We explored students' progress through audio recordings and observations in class. Although the students initially lacked statistical knowledge, they successfully used Python to apply statistical concepts to data sets. The teacher suggested including more data science topics, especially machine learning. The results indicate that adding data science content to middle school programming curricula can improve gifted students' statistical reasoning thanks to practical coding experiences. Additionally, this integration might encourage teachers to explore topics like machine learning, highlighting the benefits of combining different subjects in education.

Keywords: Gifted students; Teaching data science; Python programming; Learning statistics

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1. Introduction

Developing students' data literacy, the ability to understand, use, and communicate with data, is crucial as data science becomes more widespread. Data science involves statistical thinking, programming, and subject knowledge to solve problems, and offers a rich context for dealing with real-world issues that require statistical reasoning and creativity. Gifted students could engage early with data science since they usually show advanced thinking skills and learn faster than their peers (Dimitriadis, 2011; Tsai & Fu, 2016).

Despite the increasing awareness of data literacy (Gould, 2021), gifted students often have limited opportunities to develop advanced statistics and data science skills. At K-12 level, statistics is often taught in mathematics classes, often without any programming requirements. Such an approach can make standard curricula inadequate for meeting the needs of gifted students, thereby leading to boredom, lower achievement, disengagement from school, or decreased motivation (Albaili, 2003; Öngöz & Sözel, 2018; Smedsrud et al., 2024). Adding statistical

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programming can help students grasp abstract concepts, conduct data investigations, and develop critical thinking skills starting from a young age (Israel et al., 2015; Pršala, 2024). These activities can also promote independence and creativity, which are especially valuable in gifted education.

Since working with data is key to programming, combining statistics and programming can create meaningful learning opportunities for students. This combination allows students to pose meaningful statistical investigative questions, analyze data by creating and interpreting graphs, and make decisions using programming tools like Python (Memarian & Doleck, 2024). In Türkiye, Science and Art Centers [SACs] offer enrichment opportunities for gifted students, making them an ideal setting for introducing an interdisciplinary, programming-based data science curriculum.

This study will present a data science module using Python within information technology [IT] courses in a national gifted education program, incorporating real data science practices into middle school learning. It aims to fill the gap in domain-specific instruction for gifted students by designing and testing the module in a SAC. Therefore, this study seeks to answer the following questions:

RQ 1) How does an IT teacher design, implement, and reflect on a Python-based data science module for gifted students?

RQ 2) What work do middle school gifted students produce to demonstrate their understanding of statistics and Python programming?

2. Literature Review

Gifted students exhibit distinct learning characteristics that differentiate them from their peers (Krutetskii, 1976). Gifted students possess more memory capabilities, creativity, and intrinsic motivation (Davis et al., 2014). They are better at transferring knowledge to new situations and excel when faced with intellectual challenges. Often, these students prefer to engage in self-directed projects that enhance the complexity of their learning, rather than participating in traditional teacher-led instruction. Students who do not receive enriched learning experiences may experience a decline in their critical thinking skills, curiosity, and motivation (Coleman & Hughes, 2009; Coleman et al., 2015). Plucker and Callahan (2014) stress the importance of holistically addressing environmental, sociocultural, and individual factors to develop individual talents into giftedness. Therefore, gifted students should receive differentiated instruction tailored to their needs, readiness levels, interests, and opportunities for independent work that align with their abilities, interests, and readiness (Karaduman, 2010; Ministry of Education [MoNE], 2018; Steenbergen-Hu & Moon, 2011; Tortop, 2015).

Integrating technology into curriculum design for gifted students provides individualized learning opportunities, giving students the potential to develop their creativity and critical thinking skills (Plucker & Callahan, 2014). Among various options, programming has emerged as a valuable tool for developing the skills of gifted students. It can effectively support their problem-solving abilities, algorithmic thinking, and creativity (Israel et al., 2015; Takayama, 2025; Taylor et al., 2010; Wing, 2006). Python is a widely used programming language, and a notable example of its educational application comes from ETH Zurich. Researchers at this institution implemented a six-week Python programming course for gifted children aged 9 to 12. The course successfully engaged students by providing challenges that surpassed their regular curriculum, making the experience both educational and enjoyable.

Studies have shown promising results in integrating programming education for gifted students in Türkiye. Avcu and Er (2020) and Avcu and Ayverdi (2022) conducted research that combined design thinking with programming instruction for gifted students. Their findings indicated improvements in both programming skills and student engagement. Other studies showed that including Python programming boosts self-confidence and computational thinking (Erdem, 2018; Pršala, 2024; Sirakaya, 2019; Şen et al., 2021; Takayama, 2025; Yurdakök, 2022). These results support wider evidence on the advantages of computational thinking for talented students (Aslan, 2022).

Researchers highlight the significance of utilizing real datasets alongside programming instruction in data science education. However, there are challenges in effectively implementing these programs. In Türkiye, Science and Art Centers were established to help gifted students develop their talents and realize their potential (MoNE, 2015; Tortop, 2012). The aim is to nurture gifted students' abilities and enable them to reach the highest level of their capacities starting from elementary grades. Students admitted to SACs participate in orientation and support education, including social skills, problem-solving, group study strategies, scientific research methods, and social activities. Additionally, they are involved in individual talent recognition, special talent development, and project production programs in later years (MoNE, 2015).

Programming has been taught to gifted students in primary, secondary, and high schools through Information Technologies and Software courses at SACs (Avcu & Er, 2020). However, the responsibility for developing the content of these programs typically falls on individual teachers, which can lead to various issues. Research on Turkish SAC programs shows that this often results in inconsistencies (Avcu & Er, 2020; İlik, 2019; Konaş & Yağcı, 2016). Bozan and Savi Çakar (2020) and Çetin and Doğan (2018) highlight problems such as misalignment with student abilities, inadequate activity duration, and a lack of systematic organization. To effectively address these challenges, it is essential to observe how proposed instructional plans are implemented in the classroom and refine them accordingly (Plucker & Callahan, 2014). This iterative process helps identify areas for improvement and allows for necessary adjustments to ensure that the curriculum remains relevant, engaging, and aligned with the needs of gifted students.

Research studies demonstrate the advantages of using information and communication technologies in mathematical learning (Takayama, 2025), especially for gifted students (Vargas-Montoya et al., 2024), and highlight the necessity of integrating data science and programming education for these learners. However, there is a need for more empirical studies to evaluate specific course designs with appropriate technology and their effectiveness (Plucker & Callahan, 2014). The successful implementation requires careful attention to curriculum design, appropriate challenge levels, and the meaningful integration of real-world data applications. Finally, as Aloufi et al. (2024) noted, computer science and information technology teachers often face fewer challenges in adopting new technologies and advancements, such as new programming languages, than teachers from other specializations.

Future research should aim to develop and examine structured approaches for teaching data science using Python programming, tailored to gifted students' unique needs and capabilities. While it is clear that interdisciplinary subjects should be incorporated into information technology courses for gifted students, empirical research is necessary to assess the effectiveness of new course designs, such as teaching data science in these contexts. This study outlines the development and implementation of a course integrating data science content into Python programming at SACs in Türkiye.

3. Theoretical Framework

This study is based on two common approaches of differentiating instruction for gifted learners: enrichment and acceleration, as they effectively address the learning needs of gifted students. The enrichment approach aims to improve the depth and breadth of gifted students' individual learning experiences (Brigandi et al., 2018; Schiever & Maker, 2003). Enrichment offers opportunities outside the standard curriculum, including real-world applications and connections across subjects. It also encourages higher-order thinking skills (Renzulli, 2012; VanTassel-Baska & Stambaugh, 2006). According to Kim (2016, p. 104), enrichment programs are: "[...] organized educational activities beyond regular class activities that (a) occur during the school year or summer, (b) are organized to serve gifted students, and (c) are supervised by adults." Acceleration, on the other hand, allows students to move through the curriculum at a speed or level that suits their readiness. Appropriate acceleration approaches lead students to engage with advanced concepts earlier than their peers (Colangelo et al., 2004; VanTassel-Baska & Baska, 2019). Research

shows that enrichment and acceleration positively impact gifted students' academic, creative, and motivational outcomes (Kim, 2016; Martin, 2005). These findings have also been confirmed in well-structured enrichment formats, including those that use technology and maker-oriented approaches similar to project-based learning and data work (Baccassino & Pinnelli, 2023; Smedsrud et al., 2024).

In this study, a Python-based data science module incorporates acceleration by introducing statistical programming and data analysis concepts. Gifted students often encounter these topics in later years. At the same time, it provides enrichment by using real-world datasets, interdisciplinary problem-solving tasks, and chances for students to design, implement, and interpret their own data investigations. The instructional resources intentionally reflect these two differentiation models: acceleration ensures challenge, while enrichment fosters creativity, interdisciplinary thinking, and independent learning. Such a combination aims to keep interest in intellectual and academic development, encourage creativity, and support independent learning (Renzulli & Reis, 2014). By designing the instruction through these two approaches, the study aligns with effective practices in gifted education while allowing the module to be tailored to the specific context of SACs.

4. Method

In this study, we created a data science learning module with Python. We worked with an information technology teacher who teaches 7th-grade students at a SAC in İstanbul, Türkiye. Following an action research model, we examined how gifted students approached and experienced Python programming to improve their data skills. Action research involves a structured intervention process where people investigate their professional actions and take steps toward change (Costello, 2007) to improve instruction quality (Altrichter et al., 2000).

4.1. Study Group

The Istanbul Provincial Directorate of National Education's Survey Research Commission approved the study, recording minutes on September 19, 2022, with evaluation number 56110516/22. After receiving the Governor's approval on September 28, 2022, we got permission to conduct in-class research with teachers and students at a SAC in an Istanbul district during the 2022-2023 academic year. The Marmara University Institute of Educational Sciences Research and Publication Ethics Committee determined on February 08, 2022, with decision number 02-05, that the "Data Science with Gifted Students" research is ethically appropriate. This study followed ethical guidelines for participant involvement, data collection, and confidentiality. We sent the students and their parents a motivation letter to invite them to the class through their information technology teacher. Aloufi et al. (2024) note that computer science and IT teachers more quickly adjust to new programming tools, which helps with implementation. As a result of this open call, six students (two girls and four boys) aged 11-12, from a 7th-grade information technologies class, volunteered to participate during the 2022-2023 academic year. Therefore, all participants and their parents gave informed and oral consent.

We specifically chose 7th graders because they had completed most of the middle school curriculum's (grades 5-8) "Data Analysis" objectives. Middle school students typically take two courses in major subject areas each semester. During the Fall 2022 semester, one was an information technology course, which included two hours of Python programming each week. The class teacher graduated from a university's Faculty of Education in the Marmara region in 2009, majoring in Computer Education and Instructional Technology. He has 14 years of teaching experience, with the last two years explicitly spent as an information technology teacher.

4.2. Implementation and Data Collection

It is important to include different teaching strategies, provide independent study and exploration opportunities, and offer advanced coursework that supports the curiosity of gifted students. Within this project, we developed resources for the data science learning unit, including content

and course materials that we assumed were suitable for gifted students. The IT teacher helped us teach statistical concepts while integrating them with Python programming. His field experience was crucial in creating a curriculum where these two subjects could effectively blend, enabling students to build their programming skills and statistical thinking simultaneously. We used the resources with gifted students and updated them based on the implementation and the feedback from the teacher. Some examples of these instructional materials can be found in Appendix A. We analyzed the students' progress during and at the end of the process using notes from classroom observations and a semi-structured interview with the teacher afterward.

In this study, we provided differentiation through enrichment and acceleration. Although the teacher already taught Python programming, we adapted this module to focus on data. Basic concepts like variables, loops, and conditionals were practiced in tasks that connected coding directly to data. The teacher helped us understand the students' initial skill levels in Python and statistics, allowing us to adjust our weekly schedule accordingly. At the end of each week, we assessed the students' understanding to ensure that the content for the following week was appropriate. Additionally, students worked with a real dataset that did not have a predefined statistical investigative question, which encouraged them to look for patterns and develop their own inquiries. This setup provided a challenge while also allowing for creativity and independence.

The program created for this research included face-to-face data science and Python programming training for two hours each week over seven weeks (see Table 1). This program combined basic statistical knowledge with Python programming skills that students might need. At the same time, students applied the statistics and Python knowledge they learned through data applications. By the end of the training, students could use Python at a basic level and gained experience working with real data.

Table 1

Data Science with Python weekly content

Week	Content
1	What is statistics? Statistical concepts What is data? Types of data Classification of variables, scale types Measures of central tendency and dispersion Introduction to Python programming
2	Measures of central tendency and Python applications Measures of central dispersion and Python applications What is Numpy? Importing the Numpy library Operations with Numpy
3	Numpy library and mathematical operations Importing the Pandas library
4	Pandas data structures Pandas Dataframe
5	Dataframe applications Frequency distributions Graphical representation of qualitative and quantitative data
6	Types of spread Data visualization with Python What is Matplotlib? Loading libraries and organizing data
7	Python programming with game data: Student presentations

For six weeks, two researchers and the teacher taught students the basic data science concepts and representations. They focused on how to apply these concepts with Python using the Numpy

and Pandas libraries. Before the training started, the IT teacher had the students complete exercises in Python. When the training began, the students engaged with visual examples, followed step-by-step coding exercises, and received individualized support. They were encouraged to use data and interpret their findings with statistical measures such as mean, median, and standard deviation. They were also exposed to statistical representations like bar graphs, pie charts, line graphs, histograms, and box plots. As shown in Table 1, students were initially introduced to fundamental statistical concepts, including graphical representations for categorical, discrete, continuous, and grouped data. They developed knowledge and experience in comparing central tendency measures (mean, mode, median) and spread (range, consideration of outliers). They were given a data set and a project assignment to apply what they learned in class. Using their free time, the students worked on simplifying and differentiating the code they had written. In the seventh week, the students took turns presenting their projects to the class. During these sessions, one of the researchers helped with teaching while another observed, taking notes and recording classroom audio.

A semi-structured interview form (Appendix B) was used for data collection. This form included questions about the teacher's views on gifted education programs, common challenges, and thoughts on the data science module. The interviews took place individually, both before and after implementation. The interview form was prepared using insights from Özdemir (2016), Çetin and Doğan (2018), and Özdemir and Isiksal-Bostan (2021). Throughout the process, the authors recorded the students' work in a computer environment during lessons and the final week.

4.3. Data Analysis

The first source of data included pre- and post-implementation teacher interviews. The interviews were audio-recorded and transcribed verbatim. The unit of analysis was a meaning unit, which is a complete idea or claim, usually a short part of dialogue. For example, the conversation below between the first researcher and the teacher before implementation was seen as a meaningful unit regarding integrating Python programming with the targeted statistical content:

Teacher: You will take responsibility for the data part. We did not include these in the project as a whole. Let us think again. They can understand Python programming. Since we assumed they [the students] already know this, we will not be teaching it from scratch, so we did not write it down as a learning objective. We did not state that we would teach Python to these students. So, if in our project you say, "We must provide Python beforehand," if you are required to do that according to the project, then you should cover all of these topics – arrays, functions, sequences – first, and then move on to the mathematics.

Researcher 1: Okay.

Teacher: Or you could sprinkle them in along the way, but there must be a rationale. For example, is this included in teaching children who do not know Python? Does the project aim to teach those with no prior knowledge?

Researcher 1: No.

Teacher: What then? So, will we teach complete beginners and track their progress? Does this program measure that progression? If so, you should leave these alone. They should stay as learning objectives. Okay? Just put them back exactly as they are in the earlier draft.

We analyzed the data (both interviews and the student products) using a content analysis approach (Krippendorff, 2013). We first generated preliminary open codes from the interview transcripts. The first and the second researchers, who were also involved in teaching, collaborated to code the data. They discussed, refined, and grouped their coding into higher-order categories until they reached a consensus. The third author supervised the entire process by reviewing the codes, checking the progress, and ensuring consistency across the interviews.

5. Findings

This project aimed to create a programming-based data science learning unit for gifted middle school students in information technology courses. We implemented the project based on teacher opinions, student experiences, and their work. This study looked into the teacher's suggestions for designing and implementing a Python-based data science module for gifted middle school students and his reflections on the module after it was implemented. It also explored how these students could access data science content and improve their data literacy using Python programming. The results from these two research questions will be presented in turn in this section.

5.1. Results Related to the First Research Question

The first research question focused on the teacher's views about teaching gifted students data science and Python programming. The main themes from the interview are shown in Table 2.

Table 2

Established categories from the first interview

<i>Category</i>	<i>Description/Examples</i>
Start with the learning objectives. Then, plan the weekly content backwards.	In designing the module, begin with the learning objectives, such as "the concept of data and data types." Then, connect the specific content and tools to each week, instead of starting with the tools like Python.
Clarify the scope of the module. Start with the theory of data science. Use Python as a supporting tool.	Concepts like variable types can't be taught through Python alone. Theory sessions should support the ideas, using Python selectively to illustrate or practice, rather than replacing conceptual instruction. This approach avoids focusing solely on tools and keeps the module centered on concepts.
Keep data science goals central.	Teaching Python is not the main goal of this project. Focus on the concepts that students will really use for data work, such as basic structures and simple arrays. Consider light use of libraries, but avoid turning this into a general "learn Python" course.
Select easy-to-access datasets and avoid complex data science ideas.	Use real, suitable datasets. Focus on summary statistics, such as central tendency and variability, along with the concept of distributions and basic data visualization.
Feasibility and taking real constraints into account, such as time, space, and devices.	Keep expectations modest, such as not including TensorFlow unless time permits. Make sure tasks fit the time you have. Plan for 5 to 8 weeks, with 10 to 16 hours in total, broken into 2-hour blocks that match lab availability.
Weekly plan pattern	Focus on concepts, such as data types, distributions, center, and spread. Apply Python to support these concepts. Provide guided practice using a relevant dataset.

The categories and descriptions indicate that the teacher wanted a balanced mix of data science and Python programming in the learning module. Besides the categories in the table, the interview also discussed the roles of researchers and the teacher during the module's implementation. Time and duration of the module were also important topics. The teacher suggested planning for 5 to 8 weeks (10 to 16 hours total), in 2-hour blocks. He mentioned that he could target ten students, but could not guarantee that all participants would be fully prepared for such a course. He noted, "You cannot take every student; define selection criteria and readiness for the module clearly." Lastly, the teacher emphasized the need to ensure all permissions, such as ethical approval and parent/guardian consent, are obtained before the study begins.

The learning module, created by the teacher and researchers, took place face-to-face for two hours each week over seven weeks, as shown in Table 1. Another interview occurred after the implementation. In this interview, the teacher found the course content suitable but also offered suggestions. The most notable suggestion was to include more engaging content for students by minimizing the theoretical parts of the lectures and allocating more time to applications. He also wanted to cover a broader range of topics in the course.

The teacher noted the course's impact on students' interests. He stated, "The course increased student interest and motivation by allowing them to analyze real-life data. Using real data throughout the course made the subject more interesting." Therefore, he suggested continuing to choose data sets from games or topics that would capture children's attention. He highlighted the benefits of including Python in data science education, especially its ability to connect theoretical concepts with real-world applications:

"The contribution of data science with Python to students is great. Thanks to this new content, students gained technical knowledge and skills and made sense of the relationship between what they learned in class and daily life."

The teacher shared his struggles from his previous Python programming course. He suggested that adding data science content to Python helped address these challenges:

"In my previous Python lessons, I often heard questions like where and how we will use it daily. It was better to let them experience it directly. When we incorporate data science into programming, we answer this question in the child's mind."

Overall, the teacher feedback suggests moving away from traditional lectures and focusing more on hands-on activities and real data. He advised "quickly explaining the basic information in the beginning," which would be appropriate, especially for gifted students. Then, he believed the students would develop their skills through "creating graphs and tables, doing more graphical applications and interpretations."

The teacher recommended expanding Python with data science courses by adjusting the curriculum to include more challenging assignments. He specifically mentioned adding more advanced topics, such as machine learning. He stated, "The content allowed a deeper understanding and the ability to draw context-related inferences. Students employed Python libraries to generate graphs, which helped them analyze and interpret data without needing to view the entire dataset." He found students performed remarkably well: "They provided compelling and insightful answers to questions during their data presentations at the end of the course. Their explanations were deemed significant by the teacher, hence "exceeded the expectations for their age and educational level." These findings suggest that "the experience in this class would enable students to conduct future projects in Python and data science." This response demonstrates the students' understanding of data science concepts and their skill in applying their newfound knowledge.

The teacher strongly believed that data science education could be part of the curriculum for gifted middle school students. For the new content, however, to be effective, the number of course hours may be increased at the middle school level, and the difficulty could rise gradually as students progress:

"Data science education should start in 7th or 8th grade. I am unsure if it would be too late if it had not started by then, but it should not have been skipped in Python courses in high school. However, if it is to be applied to high school students, the difficulty may need to increase compared to what is present in this module."

The teacher suggested increasing the time spent on the content. He said,

"The implementation time of the data science module should be longer because not all students know Python. It is necessary to give them some Python knowledge before starting the module. The module is good for introducing data science. However, we may only increase the implementation duration since less time was left for the parts that students enjoy most, like data visualization. The

module should last at least 8 to 10 weeks. I think it would benefit students more if we arranged a program to build a foundation for machine learning, not just data science."

In conclusion, when comparing this project's results to his previous experiences, the teacher stated that the developed module was more helpful for the reasons mentioned here. Thus, teaching data science with Python could continue with richer content over an extended period. The findings showed that the teacher's views aimed to enrich and speed up how gifted middle-grade students learn data science and Python. From an enrichment standpoint, he noted that concepts like data types cannot be taught only through Python. Understanding data concepts should guide the lessons, with coding used to explain ideas. He also suggested using real datasets to help students grasp statistical concepts like variability and central tendency while avoiding overly advanced material. He remarked, "We are not supposed to teach linear regression to these kids, right?" These choices reflect his goal to enhance students' experiences with meaningful, age-appropriate data science applications rather than turning the course into a general programming class. His perspective also included aspects of acceleration. He pointed out that not all students would be ready, saying, "You cannot do this stuff with any student, as they are not at the same level." Before starting the learning module, he emphasized the need for clear selection criteria and readiness. He discussed streamlining content by focusing only on the essential elements of Python that would help students with their data work, while avoiding unnecessary libraries or complex structures in Python programming. These views suggest a mixed approach: enrichment through meaningful, real-world data science experiences, and acceleration through early exposure, careful selection, and focused pacing for more prepared students.

5.2. Results Related to the Second Research Question

This section will report students' statistics and Python programming progress during the learning unit and at its end. We did not expect the students to grasp basic statistical concepts fully. This was because the current curriculum covers limited statistics. Teaching data science with Python enhanced students' understanding of statistical measures, graphs, and other essential statistical ideas, improving their ability to apply these concepts meaningfully to the data. Additionally, we observed that students could evaluate and interpret questions from multiple perspectives. They used various graphs, such as dot plots and histograms, to look at and understand their findings. Overall, the students could conduct thorough statistical analyses based on their experiences in statistics and the limited opportunities provided. Table 2 shows the statistical concepts and application examples that the students generated throughout the study.

As shown in Table 2, students used statistical operations and coding for tasks like sorting data and switching between decimal and whole number formats while programming in Python. For example, in the arithmetic mean scenario, students discovered statistical concepts in various ways. Introducing libraries increased their ability to remarkably calculate the arithmetic mean, variance,

Table 2

Statistical concepts and codes employed by the students

Python Code	Description
<pre> a=15 b=36 c=13 d=18 e=19 toplama=a+b+c+d+e ortalama= toplam /5 print </pre>	The student assigned values to the letters one at a time. He then found the total of these values and divided that total by the number of letters to get the arithmetic mean.

Table 2 continued

Python Code	Description
<pre>sayı=[5,6,7,8,9,10] toplama=0 for i in range(len(sayı)): toplama= toplama+sayı[i] ortalama=toplam/len(sayı) print(ortalama)</pre>	The student made a list. He wrote a loop to find the total of the numbers in the list. He divided the total by the number of numbers in the list to get the average of the list he made.
7.5	
<pre>def Ortalamabul(girdi): toplama=sum(girdi) return toplama/len(girdi) liste=[2,3,4,4,3213721] Ortalamabul(liste)</pre>	The student first made a list. He wrote a function to find the average of the elements in this list. In this function, he calculated the sum of the elements and then divided the sum by the number of elements to get the average. The student used four similar numbers in the list and picked a very large number for the fifth number.
642746.8	
<pre>def ortalama(liste): Veriadedi = len(liste) if Veriadedi <= 1: return liste else: return sum(liste)/Veriadedi liste = [1,2,3,4,5] ortalama(liste)</pre>	The student made a list. To find the mean of this list, he created a function that addresses two cases: (i) when the number of elements is one or less, and (ii) when it is greater than one. In the first case, the student wants the single element to return itself as the answer. In the second case, when there are more than one element, the student wants the sum of the numbers in the list to be divided by the number of elements. He wants the result to be printed as the answer.
3.0	
<pre>liste = [1,3,4,8,5] liste = sorted(liste) print(liste)</pre>	The student made a list and arranged the items from smallest to largest. This allows him/her to find the median of the data set, as the median is the middle number in an ordered dataset.
[1, 3, 4, 5, 8]	
<pre>def ao(liste): return sum(liste)/len(liste) def varyans(a): k=[] for i in range(len(a)): fark=a[i]-ao(a) kareler= fark**2 k.append(kareler) p=sum(k)/len(a) return p veriler=[-10,0,10,20,30] varyans(veriler)</pre>	The student started by creating a list. He wrote a function to calculate the average of the list. In another function, he found the difference between each number and the average, squared that result, and added it to a new list. Afterward, he divided the sum of the elements in the new list by the number of elements to determine the variance of the original list.
200.0	
<pre>import pandas as pd import numpy as np b = np.array([1,2,3,5,5],dtype="int") b</pre>	The student first called the Numpy library and created an array. He wanted to print the numbers in the array as integers.
array([1, 2, 3, 5])	

Table 2 continued

<pre>import numpy as np b= np.array([1,2,3,4,5.2], dtype="float") b array([1. , 2. , 3. , 4. , 5.2])</pre>	In the next code block, the student created an array. He wanted the numbers in the array printed as decimal numbers.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
<pre>c = np.zeros((3,4)) print(c) [[0. 0. 0. 0.] [0. 0. 0. 0.] [0. 0. 0. 0.]]</pre>	The student created a 3x4 zero matrix with the Numpy library and printed the matrix.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
<pre>numpy_array = np.array([0,1,2,3,4,5,6,7,8,9]) numpy_array = numpy_array.reshape(5,2) print(numpy_array) print(numpy_array.max()) print(numpy_array.min()) print(numpy_array.sum()) print(numpy_array.sum(axis = 1)) print(numpy_array.sum(axis = 0)) [[0 1] [2 3] [4 5] [6 7] [8 9]] 9 0 45 [1 5 9 13 17] [20 25]</pre>	The student created an array and wanted to print the elements in a 5x2 format. Then, the student used the print function to calculate the maximum, minimum, and sum of the numbers in the array. The student also found the sum of the numbers in each row and the sum of the numbers in each column.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
<pre>numpy_array = np.array([0,1,2,3,4,5,6,7,8,9]) print(numpy_array.mean()) print(np.median(numpy_array)) print(numpy_array.var()) print(numpy_array.std()) 4.5 4.5 8.25 2.8722813232690143</pre>	The student created an array. He printed the arithmetic mean, median, variance, and standard deviation of the values in the array using a function.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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Sales (millions)	Block1	Block2	Block3	Block4	YearReleased	2004	2005	...	Tricks	Volleyball	Wakboarding	Wrestling	0	Nintendo DS	Super Mario 64 DS	4.69	1	1	1	1	2004	1	0	...	0	0	0	1	Sony PSP	Lumines: Puzzle Fusion	0.38	0	0	0	1	2004	1	0	...	0	0	0	2	Nintendo DS	WarioWare Touched!	0.54	0	0	0	1	2004	1	0	...	0	0	0	3	Sony PSP	Hot Shots! Golf Open Tee	0.49	0	0	0	0	2004	1	0	...	0	0	0	4	Nintendo DS	Spider-Man 2	0.45	0	0	0	0	2004	1	0	...	0	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1768	Playstation 3	Metroid Prime 3	0.04	0	0	0	0	2010	0	0	...	0	0	0	1769	Playstation 3	Prison Break: The Conspiracy	0.04	0	0	0	0	2010	0	0	...	0	0	0	1767	Nintendo Wii	Samurai Warriors: So Long, My Love	0.04	0	0	0	0	2010	0	0	...	0	0	0	1768	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1769	Sony PSP	Metroid Prime 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Table 2 continued

Python Code	Description
<pre>print(dfc.rename(columns={"US Sales": "Satış Miktarı"}).head())</pre> <pre> Console Title US Sales (millions) Block4 Block2 \ 0 Nintendo DS Super Mario 64 DS 4.68 1 1 1 Sony PSP Lumines: Puzzle Fusion 0.56 0 0 2 Nintendo DS WarioWare Touched! 0.54 0 0 3 Sony PSP Hot Shots Golf: Open Tee 0.49 0 0 4 Nintendo DS Spider-Man 2 0.45 0 0 Block1 Block0.5 YearReleased 2004 2005 ... Tricks Volleyball \ 0 1 1 2004 1 0 ... 0 0 1 0 1 2004 1 0 ... 0 0 2 0 1 2004 1 0 ... 0 0 3 0 0 2004 1 0 ... 0 0 4 0 0 2004 1 0 ... 0 0 Wakeboarding Wrestling FirstPerson Platform Isometric SideScrolling \ 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 2 0 0 0 0 1 1 1 3 0 0 0 0 0 0 0 4 0 0 0 0 1 0 1 TopDown ThirdPerson 0 0 1 1 0 0 2 1 1 3 0 1 4 0 1 </pre> [5 rows x 166 columns]	The student renamed the index 'US Sales' to 'Satış Miktarı' in the Pandas DataFrame. They then showed the table with the first 5 rows.

and other basic statistics, mainly using libraries like Numpy. Calling functions from the Numpy library sped up these operations. In summary, while students learned statistical concepts by building algorithms step by step, they became more efficient in performing these calculations with the help of libraries. This process allowed them to develop skills in both programming and statistical analysis.

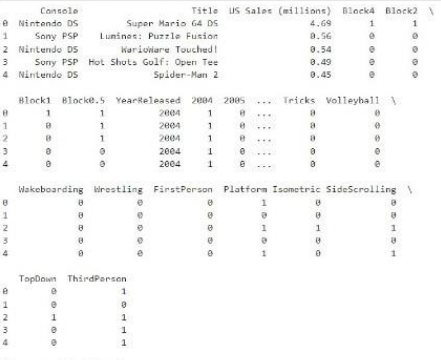
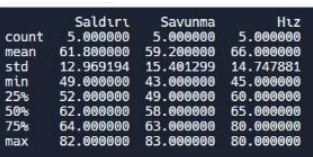
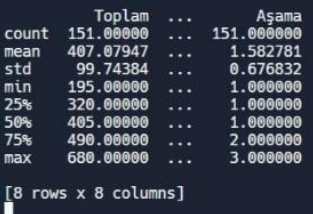
By the end of the learning unit, students examined and analyzed game data from different angles using Python. Since the game data was more complex and larger than the examples discussed in class, students first took steps to understand it. This exploration allowed them to organize and analyze the data effectively. Table 3 shows how students interpreted and made sense of the data in their projects. They organized the game data and conducted statistical analyses across different categories. Their work revealed significant attempts to uncover the relationships within the data.

Table 3

Statistical attempts toward the final data covered in the lessons

Process	Python Code	Output
Printing the index names of the data set.	<pre>print(dfc.columns)</pre> <pre> Index(['Console', 'Title', 'US Sales (millions)', 'Block4', 'Block2', 'Block1', 'Block0.5', 'YearReleased', '2004', '2005', ..., 'Tricks', 'Volleyball', 'Wakeboarding', 'Wrestling', 'FirstPerson', 'Platform', 'Isometric', 'SideScrolling', 'TopDown', 'ThirdPerson'], dtype='object', length=166) </pre>	Students understood the content of the data set by printing the index names.
Printing the names of the first five indices of the data set.	<pre>print(dfc["Console"].head())</pre> <pre> 0 Nintendo DS 1 Sony PSP 2 Nintendo DS 3 Sony PSP 4 Nintendo DS Name: Console, dtype: object </pre>	Students could see the structure of the data and what it contains by quickly previewing the contents of the "Console" index.
Changing index names using the Pandas library	<pre> import numpy as np import pandas as pd import seaborn as sns import matplotlib.pyplot as plt pk1 = pd.read_csv('Pokemon (1).csv') pk1.columns=["N","Ad","Tür_1","Tür_2","Toplan","Can", "Saldırı","Savunma","Sp_Saldırı","Sp_Savunma","Hız","Aşama","Efsanevi"] pkDes = pk1.describe() [["Toplan","Can","Saldırı","Savunma","Sp_Saldırı","Sp_Savunma","Hız","Aşama"]] print(pkDes) </pre>	By changing the index names, students could understand the data better.
On his blog, the student published the first five lines of the indexes he wrote.	<pre>print(dfc[["Console", "YearReleased"]].head())</pre> <pre> Console YearReleased 0 Nintendo DS 2004 1 Sony PSP 2004 2 Nintendo DS 2004 3 Sony PSP 2004 4 Nintendo DS 2004 </pre>	Students were able to see the structure of the data and the information it holds by doing a quick preview of the contents in the "Console" and "YearReleased" indexes.

Table 3 continued

Process	Python Code	Output
The student updated the name of the index and printed the first five rows of the data set.	<pre>print(dfc.rename(columns={"US Sales": "Satış Miktarı"}).head())</pre> 	Students changed the name of the index to make the data set easier for them to understand.
Calculating the attack, defense, speed, total, and stage variables' statistical measures includes their mean, Q1, and Q3 using a function.	<pre>import numpy as np import pandas as pd import seaborn as sns import matplotlib.pyplot as plt pk1 = pd.read_csv('Pokemon (1).csv') pk1.columns=["#", "Ad", "Tür_1", "Tür_2", "Toplam", "Can", "Saldırı", "Savunma", "Sp_Saldırı", "Sp_Savunma", "Hız", "Aşama", "Efsanevi"] pkDes = pk1.describe() [["Toplam", "Can", "Saldırı", "Savunma", "Sp_Saldırı", "Sp_Savunma", "Hız", "Aşama"]] print(pkDes)</pre>  	The student organized the statistical values. They could comment more easily based on categories. On the right in the tables, students noted that the speed category had the highest average. They also observed that the data in the defense category was more variable.

Lastly, we reviewed the students' graphs made from game data using Python. As shown in Table 4, students applied various data visualization techniques to compare the data. For instance, in the first graph in Table 4, the attack and defense scores of five characters from the game "Pokémon" were displayed using two separate line graphs. The student effectively showed that Charmander was the weakest in attack and defense based on these two factors with this graph. This indicates the student's skill in using visualization tools and making meaningful insights from the data. The second graph in Table 4 represented character types (e.g., Grass and Fire). Although this data was categorical, it is notable that the student interpreted the graph carefully and chose a suitable visualization for this data type. This example highlights the student's attentiveness to correctly analyzing and interpreting categorical data.

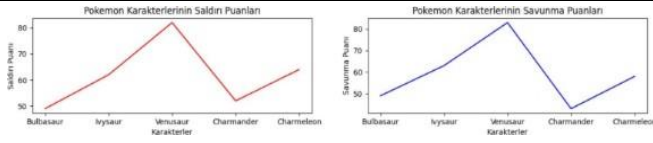
As demonstrated in Table 4, students successfully visualized game data through Python. The straightforward visualization process allowed them to work efficiently. Different graphical display options and the ability to customize colors helped to increase their interest in these tools. Students were more engaged when they could select and adjust colors during lessons. Using various colors to visualize complex data made interpretation easier and more effective. When creating visual data

Table 4

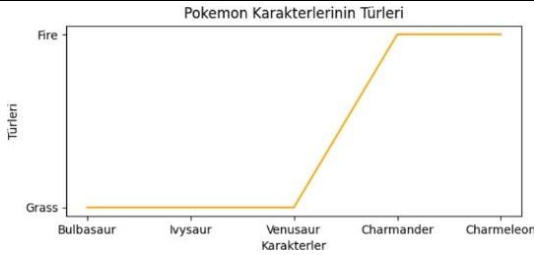
Graphs obtained from game data projects

Graph

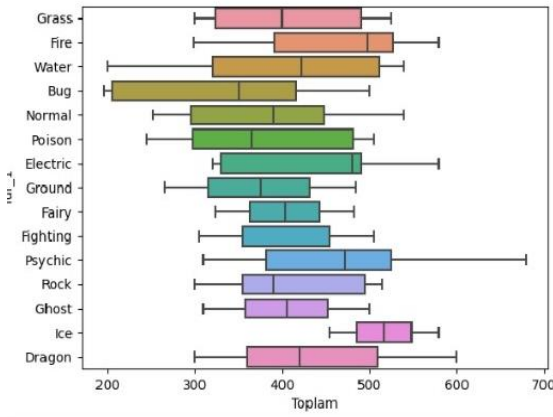
Student Comment



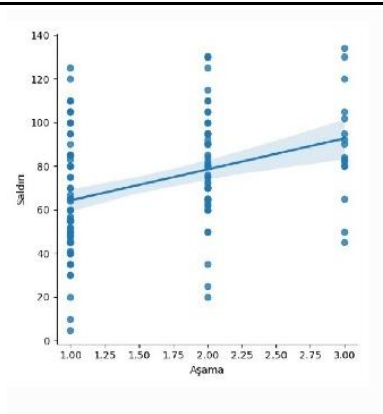
The student compared the average attack and defense scores of the five game characters. The student noted the differences in these scores and commented that the attack scores were closer to the defense scores. Through this comparison, the student mentioned that the Charmander character had the lowest score.



In the graph, the student organized information by types of characters. The student explained that he made this graph to quickly see which character fits into which category.



In the graph, the student mentioned that Ice has the highest median score. He explained that the vertical line in the center of the box represents the median value. He pointed out that Psychic shows the biggest difference between values, while Ice has the smallest difference and is the most clustered data set. He noted that choosing Ice will not surprise us, but selecting Psychic might bring an unexpected result. He also indicated that the standard deviations for Psychic and Water are larger than for the others because the Q1, Q3, and the first and last values are far from the median. He mentioned that in Fighting, the median value aligns with either the Q1 or Q3 values.

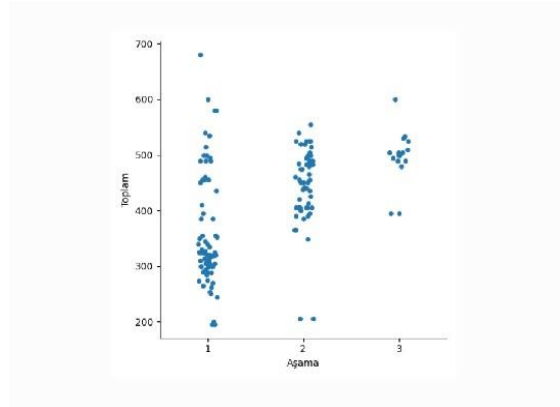


The student created a graph showing the attack scores of the characters in the dataset at different evolutionary stages. In stage 3, the student noted that the scores are more similar and there are fewer values since most characters are in stages 1 or 2. He also mentioned that the average attack scores increase from the first stage to the third stage.

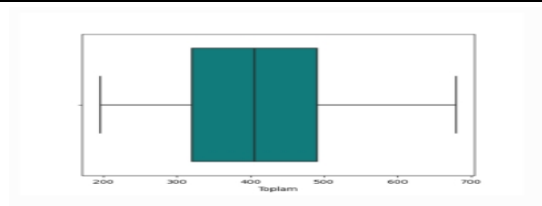
Table 4 continued

Graph

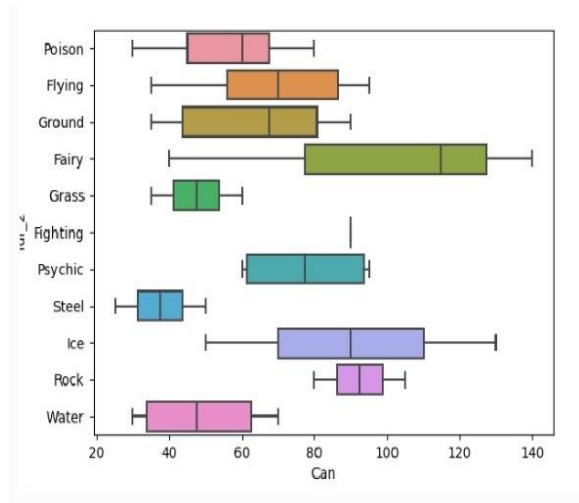
Student Comment



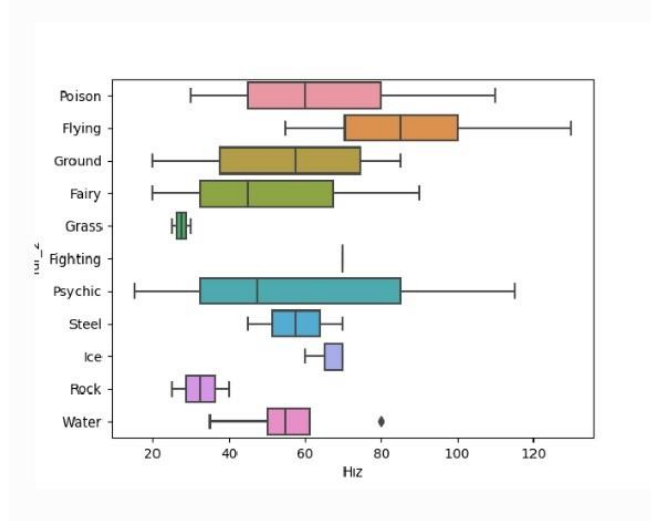
The scatterplot shows the "Stage" column in relation to the "Total" column. The student pointed out that the lowest value is in stage 3 and there are outliers in stage 2. He also noted that most characters are in stage 1.



The student said the total score is the sum of speed, health, attack, defense, sp attack, and sp defense points. The average is around 400, and the data is grouped around 400. When asked why he or she made this graph, the student explained it was because he or she was curious about how the total score was calculated.

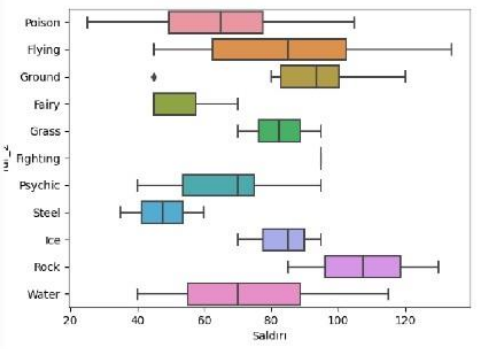
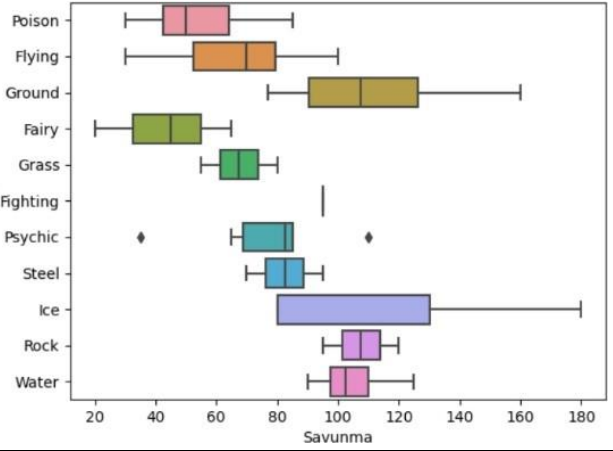
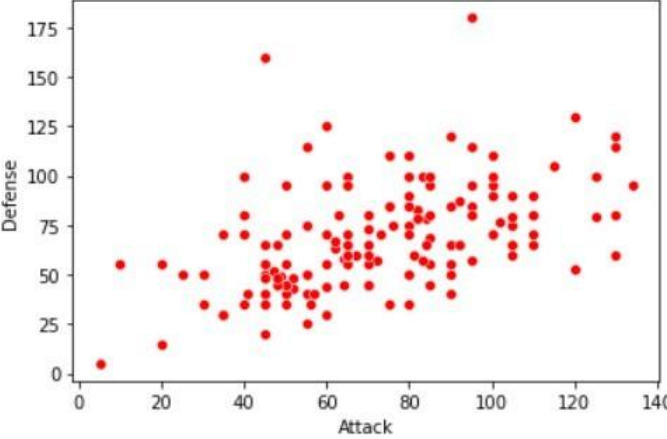


The student made a boxplot of the "Type" column in the data set based on the "Can" column. He noted that the Fighting type has the most clustering, with all values being very close or the same. She pointed out that the Fairy type is the most disorganized one.



The student created a boxplot comparing the "Type" column with the "Speed" column in the data set. He noted that most of the clustering occurs in the Fighting type, where all values are very similar or nearly the same. He suggested there might be very few characters. He also mentioned that the Psychic type shows the most variation.

Table 4 continued

Graph	Student Comment
	The student created a boxplot for the Attack column based on the types in the data set. For the Fighting type, the student noted that the values of Q1, Q2, and Q3 are the same or very similar. He mentioned that there is an extreme value in the Ground type.
	The student created a boxplot of the Defense column based on the types in the data set. He noted that there are outliers in the Psychic type. The Q2 and Q3 values are very close in the Psychic type, while in the Ice type, the median overlaps with either the Q1 or Q3 value.
	The "Attack" column in the data set was plotted against the "Defense" column. The student noted that when one variable increased, the other also tended to increase, with the attack value showing the greatest rise. He observed that most values were concentrated in the middle, with some extreme values in the attack. He suggested that a line could be drawn in the center to show the overall density.

made interpretation easier and more effective. When creating visual data representations, students often identified each variable's most suitable graph types. They could improve their decision-making skills in data analysis and visualization. The students used statistical concepts while interpreting the graphs. They included statistical measures like arithmetic mean, median, and IQR in their graphs to make the data sets more meaningful, applying visual representations while analyzing these measures. In conclusion, students' work illustrated evidence for statistical thinking. Students showed they could represent data using suitable graphs, describe distributions in terms of central tendency and variability, and interpret patterns in real-world contexts.

6. Discussion and Conclusion

In this study, we collaborated with an information technology teacher to create and execute a learning unit focused on data science using Python for gifted middle school students. As reported in the Findings section, students quickly grasped and applied basic statistical concepts to datasets. They displayed skills in data analysis and interpretation, mainly through visualizations, even with limited initial understanding and experience with data. Our teaching approach with real-world data embodies a common teaching principle, allowing students to engage with data sets relevant to their environment. The students could apply fundamental statistical concepts to datasets, aligning with findings from similar studies on accelerated learning in gifted education (VanTassel-Baska & Little, 2011). They developed skills in analyzing and interpreting data, mainly through visualizations, even though their initial understanding and experience with data and statistical concepts were limited. The findings suggest integrating data science into Python programming could benefit gifted students in middle grades. This integration can enhance students' understanding and involvement in data investigations within programming courses, supporting the broader goals of computational thinking development (Grover & Pea, 2018).

Feedback from the teacher indicates that incorporating data science into Python lessons makes programming content more relevant, helping students see how they can apply their skills to real data. The initially abstract and complex Python programming language gained meaning with the implemented project, enabling participants to apply their programming skills and use them in data-driven decision-making processes, supporting findings on the importance of contextual learning in programming education (Maloney et al., 2010). Studies by Fox and Farmer (2011), Psycharis and Kallia (2017), and Rosenberg and Jones (2024) show that programming instruction supports students' inquiry abilities and prepares them to tackle open-ended problems. Similarly, participants in this study carried out statistical investigations and applied their knowledge of real data through programming. This approach enables students to engage with statistical processes, such as developing statistical research questions, accessing and collecting data, properly representing data, assessing changes, and making inferences and predictions (Bargagliotti et al., 2020). This study supports programming integration in statistics and data science education (Çetinkaya-Rundel et al., 2022; Çetinkaya-Rundel & Ellison, 2020).

Regarding integrating Python and statistics, we see this approach as universally valuable for combining mathematical thinking with computational skills. STEM programs (English & King, 2019) could benefit from this integrated approach, particularly as 21st-century skills become more important. Choosing Python, a standard programming language, enhances the global usefulness of this method.

A structured approach to teaching Python could include essential aspects of data science. Basic programming concepts like variables, data types, control flow (if statements, loops), and functions could serve as an introduction to fundamental concepts. Basic data science skills could be included, including data analysis and visualization using libraries such as Numpy, Pandas, and Matplotlib. Students' effective use of graphs to visualize and analyze data, as shown in previous studies (Konold et al., 2015; Lehrer & Schauble, 2007), highlights their ability to improve data understanding and deliver key insights about their data. Learning programming with statistics could provide a foundation for gifted students to delve into more advanced topics, such as data science and machine learning projects (Taylor et al., 2010; Lockwood & Mooney, 2018). Given the significant role of software and programming in data science, caution must be exercised to ensure that these aspects do not overshadow the essence and objectives of data science as a teaching field (Memarian & Doleck, 2024).

The study's delimitation to specific age cohorts and the absence of longitudinal assessment metrics limit our ability to evaluate the instructional unit's efficiency. The learning unit's effectiveness could be improved by extending its duration, incorporating more visuals for the theoretical part, and selecting more engaging and complex datasets. We recommend applying the model to different age groups and levels and investigating the long-term effects. By lengthening

and deepening the learning unit, participants will be better prepared in data science, reinforcing their theoretical understanding and enabling them to work on more advanced projects.

Another limitation is the study's lack of a single established differentiation model as its framework. Instead, our design broadly follows the principles of enrichment and acceleration. While this flexibility helped tailor the module to our context, the study cannot directly claim alignment with a particular differentiation theory. Future research could enhance this work by grounding similar interventions within a specific model to strengthen theoretical framing and comparability across studies. Furthermore, this study only considered teachers' opinions and did not gather students' direct thoughts on the data in Python programming. As a result, the findings may lack depth. Future research should include student perspectives to improve triangulation and provide a more complete view.

The main challenges in implementing these recommendations may include curriculum intensity, class time constraints, teacher training needs, and technical infrastructure requirements. On the other hand, the students' high motivation and the experience of the IT teacher strongly support these recommendations. Additionally, providing teachers with further training in data science and Python tailored to this field can enhance the success of this process. These suggestions will improve the quality of instruction and further develop gifted students' analytical thinking and problem-solving skills.

Future research directions could examine the generalizability of this instructional unit across varied age groups and academic levels while implementing longitudinal assessment means to evaluate learning outcomes. Additionally, the study involved a sample size of only six students, raising concerns about the findings' broader applicability. A limited number of participants can result in a lack of diversity in experiences and perspectives, making it difficult to draw reliable conclusions that can be generalized to a larger population. While the findings offer valuable insights, they should be interpreted carefully due to the limited sample size. Therefore, the results may not accurately reflect the behaviors or opinions of other students beyond this small group. Future research with a larger and more diverse sample would be necessary to validate the findings.

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Conflict of Interests: The authors have no competing interests to declare that are relevant to the content of this article.

Data Availability: Due to the qualitative nature of the research, the data (e.g., interview transcripts and internal documents) are not publicly available. However, anonymized excerpts could be available upon reasonable request.

Ethics Committee Approval: Marmara University Institute of Educational Sciences Research and Publication Ethics Committee, on 08.02.2023, with decision number 02-05, determined that the research titled "Data Science with Gifted Students" is ethically appropriate.

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Informed Consent: All participants and their parents gave written informed consent.

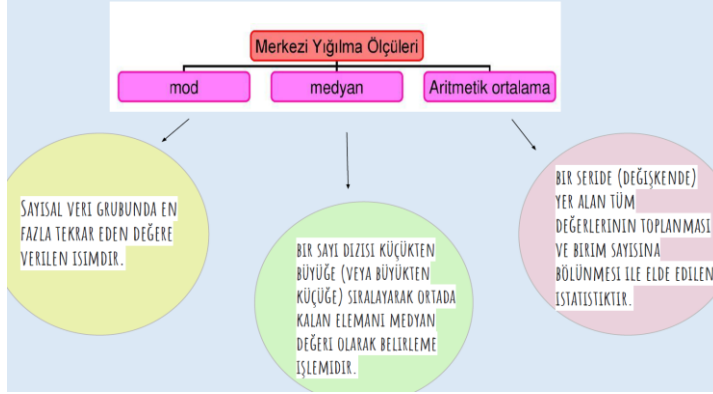
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Appendix A. Example Pages from the Instructional Units



KÜTÜPHANELER KULLANILMADAN MOD, MEDYAN VE ARİTMETİK ORTALAMA HESAPLAMA

KÜTÜPHANELER KULLANILMADAN ARİTMETİK ORTALAMA HESAPLAMA

```

disi=[40,50,60,70,30]
toplam=0
ortalama=0
for i in range(0,len(disi)):
    toplam+=disi[i]
ortalama=toplam/len(disi)
print("Toplam : ",toplam)
print("Ortalama : ",ortalama)

# list of elements to calculate mean
n_num = [1, 2, 3, 4, 5]
n = len(n_num)

get_sum = sum(n_num)
mean = get_sum / n

print("Mean / Average is: " + str(mean))
  
```

ÇALIŞMA : HERHANGİ BİR KONUDA KULLANICIYIN GİRDİĞİ 5 SAYISAL DEĞERİN ORTALAMASINI BULMA.

FONKSİYON KULLANILARAK ARİTMETİK ORTALAMA, MOD, MEDYAN HESAPLAMA

ARİTMETİK ORTALAMA HESAPLAMA:

```

def ortalamaBul(vektor):
    veriAdedi = len(vektor)
    if veriAdedi <= 1:
        return vektor
    else:
        return sum(vektor) / veriAdedi
  
```

MEDYAN BULMA:

```

def medyanBul(vektor):
    vektor = sorted(vektor)
    veriAdedi = len(vektor)
    if veriAdedi % 2 == 1:
        return vektor[veriAdedi // 2]
    else:
        i = veriAdedi // 2
        return (vektor[i - 1] + vektor[i]) / 2
  
```

Appendix B. Interview Questions

1. What do you think about the data science unit in general?
2. What would you like to say about the use and applicability of the data science unit?
3. How did the content differ from the materials you used in your information technologies courses for gifted students?
4. If you evaluate the content according to the middle school level, what would you say about the difficulty level?
5. How (do you think) the students in the class reacted to the use of this content?
6. In your opinion, how did the students find the content interesting/boring/regular/routine?
7. In general, what do you think are the benefits of this content for the gifted children?
8. What are the main advantages of the content for gifted children?
9. What disadvantages (if any) does the content have for gifted children?
10. What are your suggestions for improving the content?
11. How do you think this content can be used most effectively?
12. Finally, share your overall impressions of the content.