International Journal of Institutional Research and Management
International Institute of Applied Informatics
2026, Vol. 10, No. 1, IJIRM911

Bridging Data Science and Information Literacy: Tableau Integration and Assessment Variability in a University-Wide First-Year Course

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Abstract

This paper presents an analysis of implementing a university-wide data science education initiative at Hokuriku University, focusing on the integration of Tableau visualization platform and multi-instructor assessment management. The study examines data from 1,004 first-year students across four faculties over two academic years (2022-2023), analyzing both learning outcomes and assessment patterns among different instructors. Results indicate that while Tableau integration enhanced student engagement through hands-on analysis of real-world campus data, with completion rates exceeding 90% across most departments, significant variations emerged in grade distributions among instructors despite standardized assessment criteria. Statistical analysis using Kruskal-Wallis tests and Dunn's test with Bonferroni Correction revealed specific patterns in these variations, suggesting the influence of both instructor assessment styles and student population characteristics. These findings provide valuable insights for institutions implementing similar university-wide data science education programs, particularly regarding assessment standardization in multi-instructor environments.
Keywords: Data science education, Tableau, Assessment standardization, Higher education curriculum.

1 Introduction

The rapid advancement of digital technologies and their widespread adoption have fundamentally transformed how society interacts with data and information. A striking illustration of this transformation can be observed in the contrasting adoption rates of different technologies: while it took 64 years for airlines to reach 50 million passengers after the establishment of the first

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commercial airline in 1909, the mobile game Pokémon Go achieved the same number of users in just 19 days [1].

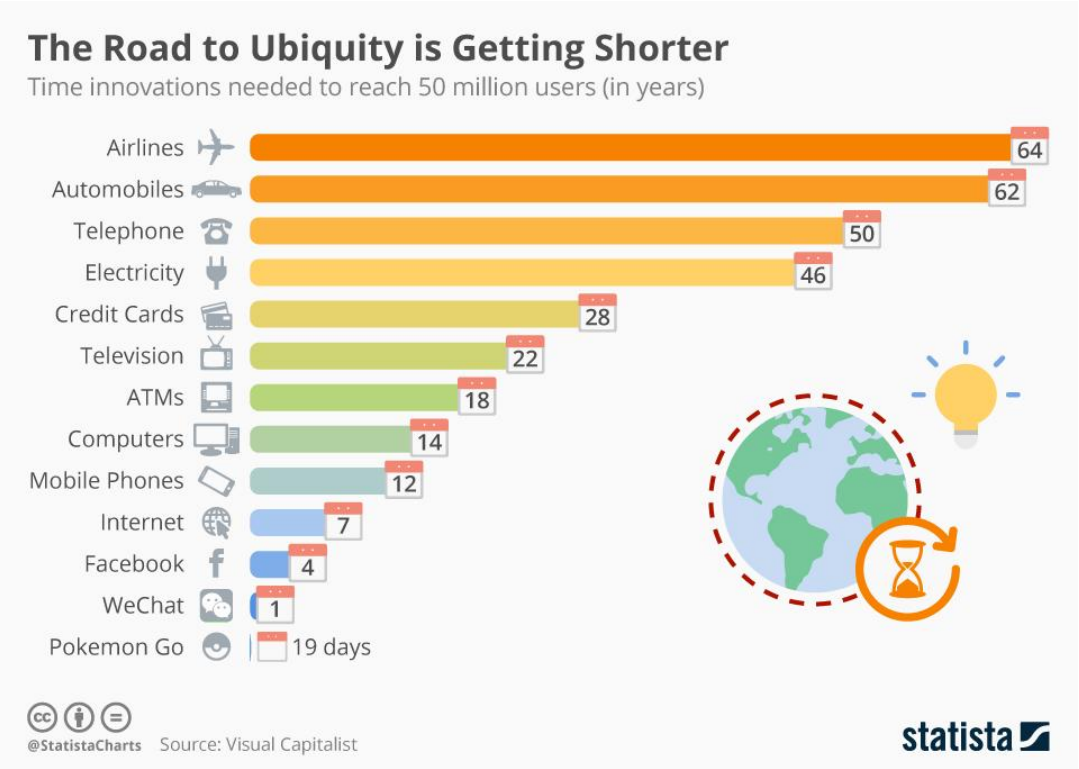

Figure 1: Time taken by innovations to reach 50 million users (in years) [1]

This acceleration in technology adoption illustrates a broader trend in the increasing speed of technological diffusion. The case of ChatGPT provides an even more remarkable example, achieving 100 million users within just one month of its launch in November 2022 [2]. This unprecedented rate of adoption highlights the exponential acceleration of innovation diffusion in the modern era, as groundbreaking technologies can now spread globally in a matter of days or weeks.

The emergence of Society 5.0, a human-centered society that balances economic advancement with the resolution of social problems through the integration of cyberspace and physical space, has further emphasized the importance of data literacy [3]. The Japanese government has positioned artificial intelligence (AI) as a fundamental technology for realizing this vision, establishing the first national AI strategy in 2019 [4]. This strategy set an ambitious goal of preparing 600,000 individuals annually with basic literacy in mathematics, data science, and AI, corresponding to the approximate number of university entrants in Japan.

In response to these national initiatives, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the Approved Program for Mathematics, Data Science, and AI Smart Higher Education (MDASH) [5]. From 2021 to 2023, this program has certified 300 institutions at the literacy level and 200 at the advanced literacy level. However, implementing these programs effectively across diverse academic disciplines while maintaining educational quality presents significant challenges for higher education institutions.

This study examines these challenges through a comprehensive analysis of Hokuriku University's Data Science and AI Education Program, which was launched in 2022 [6], [7]. The program

represents an innovative approach to data science education, incorporating the business intelligence tool Tableau into a mandatory first-year information literacy course. Tableau is a data visualization platform designed for analyzing and presenting complex datasets through intuitive drag-and-drop interfaces and interactive dashboards. Unlike traditional spreadsheet software, Tableau enables users to create sophisticated visual analytics without extensive programming knowledge, making it an accessible yet powerful tool for introducing data science concepts to students across diverse academic disciplines.

This study addresses two fundamental aspects of implementing data science education programs in higher education. First, we examine how universities can effectively implement comprehensive data science education programs that serve students across all disciplines while maintaining educational quality and consistency. Second, we investigate the challenges and solutions in managing multi-instructor data science courses, with particular attention to assessment consistency and student performance evaluation.

Building on these research questions, we explore two key hypotheses. We posit that the integration of industry-standard visualization tools, specifically Tableau, into introductory data science courses enhances student engagement and learning outcomes across diverse academic disciplines. Furthermore, we hypothesize that while regular collaboration and standardized assessment criteria among instructors can help maintain grading consistency, some variation may persist due to differences in student populations across class sections.

The significance of this research lies in its practical contribution to the implementation of data science education programs in higher education. Our study analyzes data from 1,004 students across four faculties over two academic years (2022-2023), as shown in Table 1. This comprehensive dataset allows us to examine both the pedagogical effectiveness of integrating modern visualization tools and the administrative challenges of managing multi-instructor courses.

The digital transformation (DX) of education, which has been increasingly discussed in Japan, provides an important context for our study. As Stolterman and Fors argue [8], DX refers to the improvement in people's lives in all aspects owing to the use of IT. In the context of higher education, this transformation necessitates not only the adoption of new technologies but also the development of effective teaching and assessment methodologies.

The following sections present our methodology, results, and recommendations for implementing effective university-wide data science education programs that balance standardization with the flexibility needed to serve diverse student populations. Our findings contribute to the growing body of research on data science education and provide practical insights for institutions developing similar programs.

2 Methods

2.1 Prior Research and the Learning Environment

A feature of the Data Science and AI Education Program at Hokuriku University is the adoption of Tableau Desktop, a business intelligence (BI) tool for visual analysis mainly used in business companies, in the first-year information literacy course. Because this course is mandatory, more than 500 first-year students from four faculties have been studying Tableau every year since the program began in 2022.

There are still few cases of Tableau being introduced in university courses. Hoelscher and Mortimer developed a case study that used Tableau to analyze accounting data and implemented it in their classes at a public university in the Midwest. Their results showed that students found

Tableau to be more user-friendly than Excel for visualization. Their study suggested that Tableau could be an effective tool for teaching data visualization in accounting classes [9]. Further, Batt et al. [10] developed a Tableau tutorial that analyzed the gender wage gap data, as Tableau is not used in economics education.

In Japan, Taisho University has been using Tableau in its data science courses since 2020 [11]. Since 2021, Tableau has been used in courses for first- and second-year students in all six faculties. In the classes, students work on problem-solving exercises using real data provided by a local government and several companies. Since 2022, Hokuriku University has been offering a blended information literacy course for all first-year students [12]. The course combines traditional information literacy topics with newly introduced data science content using Tableau [13]. Tableau Version 2023.1 was used in 2023 courses. Since the 2019-20 academic year, Hokuriku University has mandated that students bring their laptop personal computers (PCs), and some faculties also allow the use of MacBooks. Accordingly, the university has created supplementary videos to address the differences in Tableau operations between Windows and Mac, which are provided to the students. As shown in Figure 2, many students watched the videos on the LMS (Learning Management System) using their smartphones while operating Tableau on their laptop computers.

With the increasing capabilities of modern laptops and the availability of high-functionality, user-friendly business tools via academic licenses, as well as the abundance of open data and machine learning models, this is the appropriate time for universities to embrace a Bring Your Own Device (BYOD) policy as a means to provide hands-on data science education. The limitations of computer labs, with their restricted number of devices and time constraints, can significantly hinder the potential benefits of such programs. This BYOD policy also enabled a dual-screen, self-paced in-class learning model. As illustrated in Figure 2, students used their smartphones to watch instructional videos—allowing them to pause and rewind as needed—while simultaneously performing exercises on their laptops. This approach was designed to prevent students from falling behind, a common challenge in traditional instructor-led demonstrations.

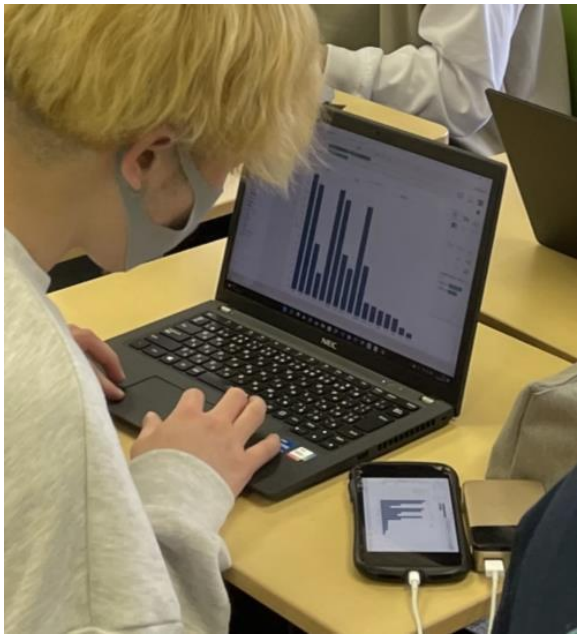

Figure 2: The dual-screen, self-paced learning model in practice, allowing students to use a smartphone for video instruction and a laptop for exercises

2.2 Program Design and Implementation

The Data Science and AI Education Program at Hokuriku University was designed to serve approximately 2,400 students across four faculties: Pharmaceutical Sciences, Health and Medical Sciences, Economics and Management, and International Communication [6]. The program's foundation was established through several key infrastructure decisions implemented in 2020, including BYOD and the adoption of cloud platforms such as Google Workspace for Education and Office 365 Education [7].

Table 1: Information Literacy Course Content

		Information Literacy Section (60 min)		**Data Science Section (30 min)**	**Apps & Services Used**
Unit 1 -Getting Started-	Week 01	Introduction	Basic PC Skills and Typing		Teams
	Week 02	Online Communication	PC Settings and Email		Teams and Gmail
	Week 03	Short Essay	Formal Email and Writing a Short Essay	Video Lecture: "Everyone is Data People"	Word, Printing on Campus
	Week 04	Collaborative Presentation	In-campus Fieldwork	Tableau Exercise I	PowerPoint
Unit 2 -Understanding the Computer-	Week 05	How a PC Works	Setting Up PC and Cloud Drive	Tableau Exercise II	Google Drive
	Week 06	Information Ethics & Information Security		Tableau Exercise III	Windows Defender
	Week 07	Introduction to AI	Experiencing AI	Tableau Exercise IV	Bard and Teachable Machine
Unit 3 -Information Gathering and Analysis-	Week 08	Web Survey	Short Questionnaire	Video Lecture: "How to Analyze Supermarket Sales"	Google Forms
	Week 09	Freshman Public Opinion Survey I	Creating a Web Survey Form	Tableau Analysis Competition I	Google Forms
	Week 10	Freshman Public Opinion Survey II	Analysis of Survey Data	Tableau Analysis Competition II	Excel
	Week 11	Freshman Public Opinion Survey III	Creating a presentation		PowerPoint
Unit 4 -Data Analysis and Report Writing-	Week 12	Typing Data Analysis I	Analyzing Typing Data	Tableau Analysis Competition Award Ceremony	Excel
	Week 13	Typing Data Analysis II	Analyzing Typing Data		Excel and Tableau
	Week 14	Writing a Term Paper	Writing a Data Analysis Report		Word
	Week 15	Using a Proofreading Tool	Peer Review, Final Typing Test		Word

The core component of the program is a mandatory information literacy course for all first-year students, which underwent significant redesign in 2022. As shown in Table 2, the 90-minute weekly sessions were restructured to include both traditional information literacy content (60 minutes) and dedicated data science instruction using Tableau (30 minutes) [14]. This integration of Tableau, a business intelligence tool primarily used in industry, represents a novel approach to introductory data science education in Japanese universities.

2.2 Course Organization and Delivery

The course implementation followed a carefully structured approach to ensure consistent quality across all sections. Each class consisted of 40-60 students, with dedicated instructional teams comprising both a primary instructor and a student assistant. A faculty member serving as the program coordinator managed the overall course organization and maintained consistency across sections. To facilitate coordination and maintain teaching quality, instructors and student assistants participated in weekly online meetings where they discussed teaching strategies, shared experiences, and planned upcoming content.

Table 2: Number of students registered and passed in each faculty.

Year	Faculty	# of Classes	# of Registrations	# of Passes	Passing Rate
2022	Pharmacy	1	67	67	100.0%
	Health & Medical	1	68	68	100.0%
	Economics & Management	4	219	166	75.8%
	Int'l Communication	3	123	116	94.3%
	subtotal	*9*	*477*	*417*	*87.4%*
2023	Pharmacy	1	62	61	98.4%
	Health & Medical	2	126	126	100.0%
	Economics & Management	5	241	207	85.9%
	Int'l Communication	2	98	92	93.9%
	subtotal	*10*	*527*	*486*	*92.2%*

The program's reach extended across multiple departments, as detailed in Table 1, necessitating careful attention to maintaining consistent educational standards while accommodating the diverse needs of different student populations. The student assistants, selected based on their strong performance in previous information literacy courses and interest in data science, received specialized training in both Tableau usage and effective pedagogical support methods.

2.3 Educational Materials and Resources

The development of educational materials involved substantial collaboration with industry partners to ensure real-world relevance and practical applicability. Through partnership with Salesforce Japan, the program incorporated four comprehensive 30-minute instructional videos covering fundamental Tableau functions [6]. These materials were supplemented with custom-created content addressing platform-specific differences between Windows and macOS systems, ensuring seamless learning experiences regardless of students' choice of operating system.

One important aspect of data science education is the use of real-world data. This engages students by motivating them to uncover hidden truths in the real world, leading them to immerse themselves enthusiastically in their assignments or projects. Hokuriku University collaborated with the companies operating campus stores and cafeterias, providing students with sales data of the stores and cafeterias from 2022 and 2023, respectively. They solicited proposals in class to increase sales.

2.4 Assessment Framework

The assessment system, as illustrated in Table 3, was designed to evaluate students' progress comprehensively through multiple components. The framework allocated 40 percent of the total grade to continuous assessment through weekly mini-assignments, ensuring regular engagement with the course material. Task set evaluations, accounting for 30 percent of the final grade, assessed students' practical application of learned concepts through rubric-based evaluation. A significant term paper component (20 percent) required students to demonstrate their analytical and writing skills, while a final typing test (10 percent) evaluated technical proficiency.

Table 3: Grading Criteria

Points	Main Category	Subcategory
40	Submission of Mini Assignments in each session	Submission of screenshots, sending emails, responding to surveys, etc.
30	Evaluation of Task Sets based on a rubric	Week 10: Tableau Analysis Competition Week 11: Freshman Public Opinion Survey PowerPoint Week 13: Excel Analysis of Typing Data
20	Evaluation of the Term Paper based on a rubric	Week 15: Term Paper of Typing Data Analysis
10	Final Typing Test Score	Week 15: An additional 1 point for every 10 points above 100.

2.5 Data Collection and Analysis

The research methodology encompassed a comprehensive data collection effort over two academic years (2022-2023). Quantitative data included detailed student performance metrics across all assignments, comprehensive grade distributions by instructor and class section, and placement test scores in both Japanese and English. Course completion rates were tracked across all faculties to evaluate program effectiveness.

The statistical analysis employed several sophisticated approaches to examine grade distribution patterns and assessment consistency. To investigate grade distribution differences among instructors, Kruskal-Wallis tests were conducted. The Kruskal-Wallis test is a non-parametric method used to compare the medians of multiple groups. When significant differences were identified, Dunn's test with Bonferroni correction, was used for pairwise comparisons to identify which specific groups differed.

Figure 3 presents the box-and-whisker plot analysis of placement test scores, providing insight into the academic preparation levels across different class sections. The box-and-whisker plots of Japanese and English placement test scores (Figure 3) revealed relatively consistent academic preparation levels across class sections in 2022. However, 2023 data showed notable variations, particularly in Class E, where students demonstrated lower average academic abilities compared to other sections.

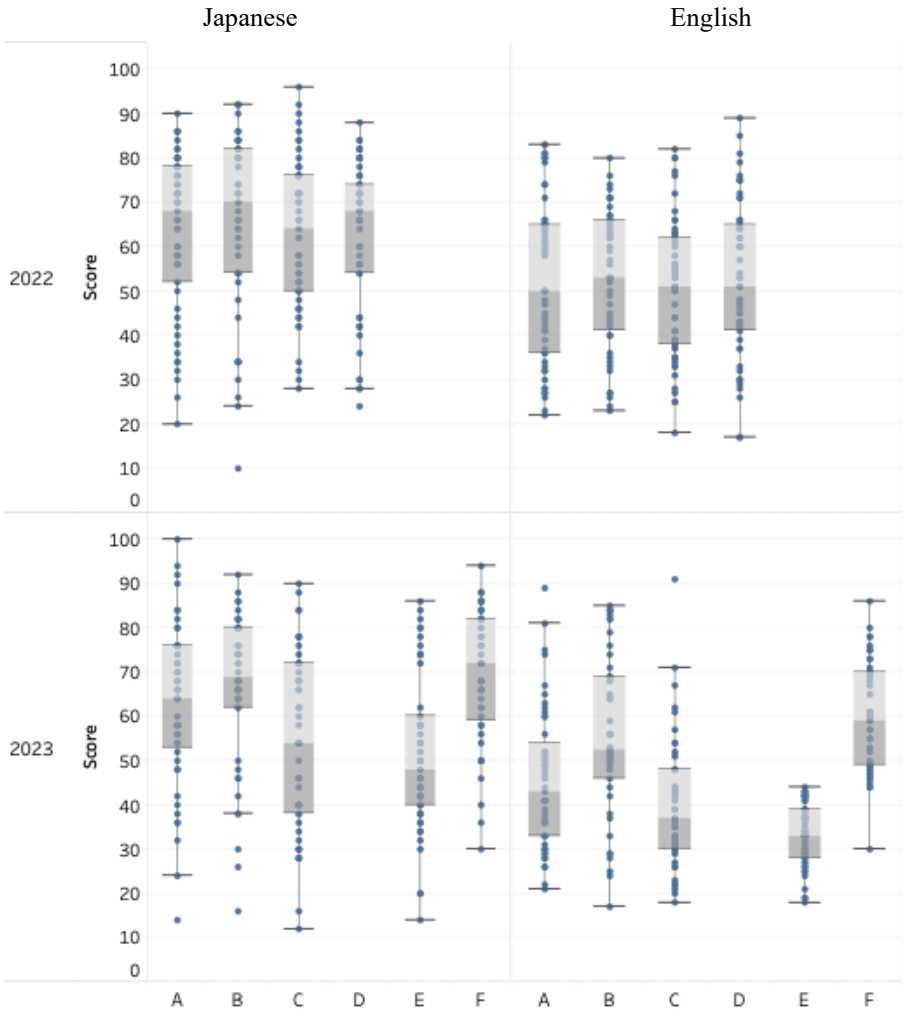

Figure 3: Placement Test Scores by Classes

2.6 Quality Assurance Measures

The program incorporated multiple quality assurance mechanisms to maintain consistent educational standards across all class sections. Instructors participated in regular training sessions focusing on both technical content and pedagogical approaches. The standardized assessment rubrics were regularly reviewed and refined based on instructor feedback and student performance data. A system of peer observation and feedback provided additional quality control, while the student assistant training program ensured consistent support across all sections.

This comprehensive methodological approach enabled thorough examination of both program implementation effectiveness and assessment consistency challenges. The combination of quantitative performance metrics and qualitative instructional feedback provided robust evidence for evaluating program success and identifying areas for enhancement.

3 Results

3.1 Program Implementation Outcomes

The Data Science and AI Education Program demonstrated substantial reach across Hokuriku University's student population over the 2022-2023 academic years. Analysis of enrollment and completion data revealed significant participation across all four faculties. In the 2022 academic year, the program served 477 students across nine classes, achieving an overall pass rate of 87.4%. Table 1 shows that the program's scope expanded in 2023 to accommodate 527 students across ten classes, with an improved overall pass rate of 92.2%.

Faculty-specific analysis revealed varying levels of student success. The Faculty of Health and Medical Sciences consistently achieved the highest pass rates, maintaining 100% completion in both years. The Faculty of Pharmaceutical Sciences showed similar success, with pass rates of 100% in 2022 and 98.4% in 2023. The Faculty of International Communication maintained strong performance with pass rates above 90% across both years. The Faculty of Economics and Management, while showing improvement, demonstrated comparatively lower pass rates, moving from 75.8% in 2022 to 85.9% in 2023.

3.2 Assessment Distribution Analysis

Statistical analysis of grade distributions revealed interesting patterns in assessment outcomes across different instructors and class sections. The grade distribution analysis, as shown in Figure 5, indicated that in 2022, despite using standardized assessment criteria, there were notable variations in grade assignments among instructors. Instructor A demonstrated a tendency toward more lenient grading, while Instructor D showed a more stringent approach to assessment.

The 2023 data revealed a shift in these patterns. While grade composition percentages showed greater consistency among most instructors, significant differences emerged in pass/fail ratios between classes. Statistical testing using the Kruskal-Wallis method revealed no significant differences in grade distributions during 2022, but identified statistically significant variations in 2023. Further analysis using Dunn's test with Bonferroni Correction identified significant differences between three specific pairs of classes: Classes A and B, Classes B and E, and Classes A and F.

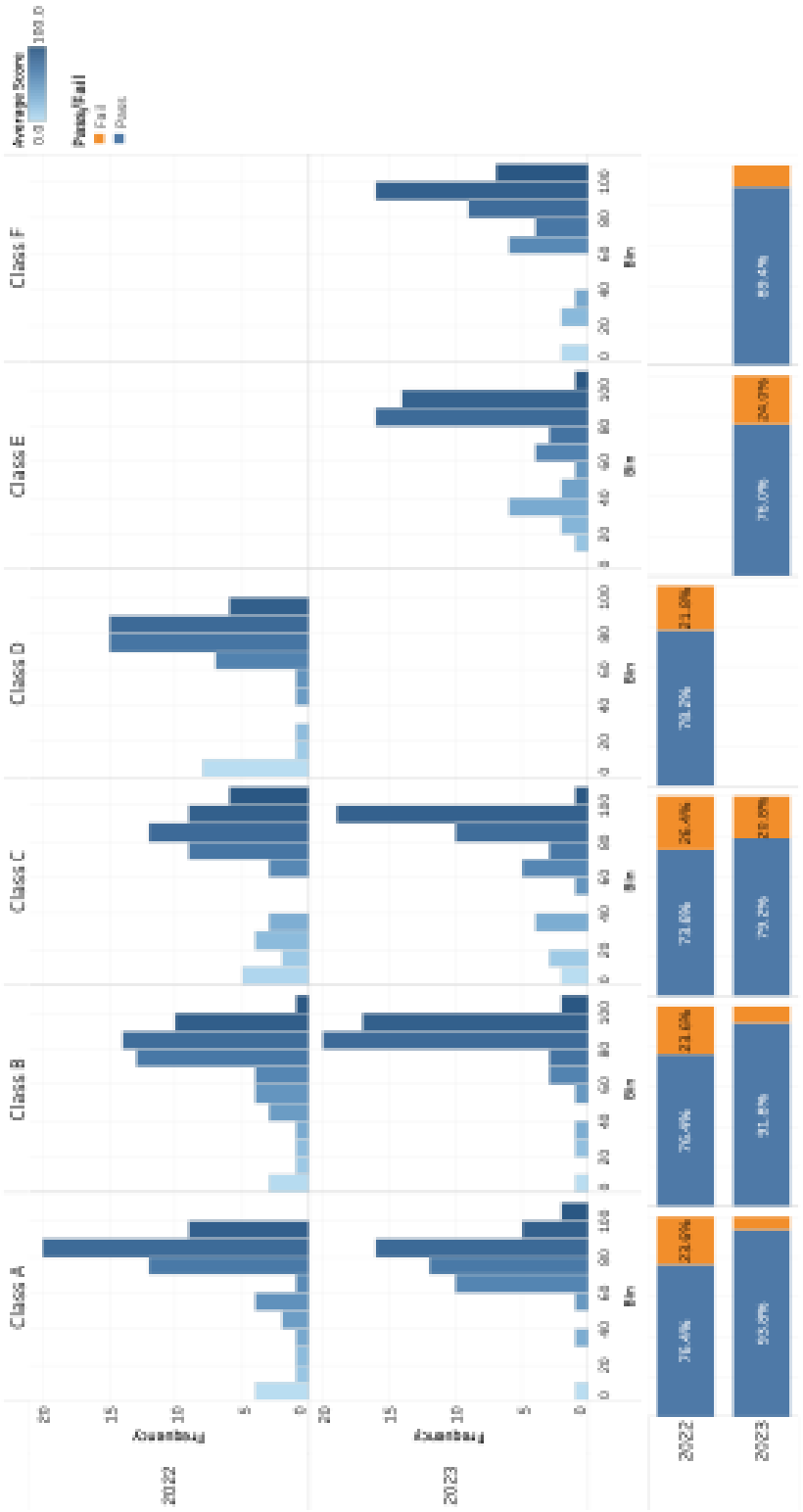

Figure 4: Class-Specific Grade Distributions and Pass/Fail Ratios

3.3 Tableau Integration Outcomes

The integration of Tableau into the curriculum yielded positive engagement results, particularly evident in the Tableau analysis competition outcomes. Students demonstrated increasing proficiency in data visualization and analysis skills through their work with real-world campus data. The program's emphasis on practical applications resulted in meaningful analytical projects, with students developing insights into campus store and cafeteria operations [15].

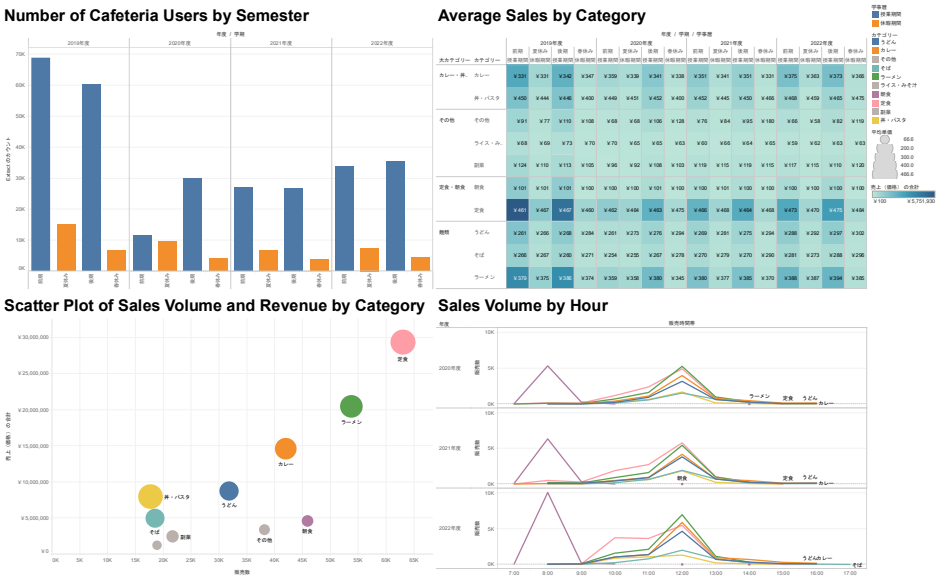

Figure 5: An exemplary student dashboard analyzing campus operational data

The quality of student work, exemplified by the winning entries in the Tableau analysis competition, demonstrated sophisticated use of visualization techniques and analytical thinking. Figure 5 shows an example of a Tableau dashboard created by students, which synthesizes multiple visualizations—including bar charts, a scatter plot, and line graphs—to analyze campus cafeteria operations. The visualization demonstrates how students identified sales patterns and peak usage times, and from these insights, formulated data-driven recommendations for improving campus services. Students successfully applied their learning to real-world data sets, creating meaningful visualizations and deriving actionable insights from campus operational data.

3.4 Instructor Coordination Impact

The weekly online meetings and standardized assessment criteria showed positive effects on teaching consistency. However, analysis revealed that these coordination efforts did not eliminate assessment variations among instructors. The data suggested that while structural elements of the program supported consistent education delivery, individual instructor characteristics and student population differences continued to influence assessment outcomes.

These results provide significant insights into both the successes and challenges of

implementing a university-wide data science education program. The findings demonstrate the program's overall effectiveness while highlighting areas requiring additional attention, particularly in maintaining assessment consistency across multiple instructors and diverse student populations. The analysis supports our initial hypothesis regarding the positive impact of Tableau integration on student engagement, while suggesting more complex dynamics in assessment standardization than initially proposed.

4 Discussion

4.1 Implementation Success and Challenges

The analysis of Hokuriku University's Data Science and AI Education Program reveals implementation outcomes and operational challenges. The program achieved completion rates of 87.4% in 2022 and 92.2% in 2023. Three key structural elements characterized the implementation.

First, each 90-minute session was divided into 60 minutes of traditional information literacy instruction and 30 minutes of Tableau-based data science education. The Tableau component utilized pre-recorded instructional videos from Salesforce Japan (four 30-minute modules) and in-class practice exercises. This time allocation was determined based on typical video completion and exercise times observed during pilot testing.

Second, the program incorporated four years of sales transaction data (2019-2022) from campus retail operations into student projects. This pedagogical approach, which centers on a complex, real-world problem, aligns with the principles of authentic learning [16]. The use of genuine data is also a core recommendation in statistics education to foster practical understanding [17]. Data preparation involved establishing data-sharing agreements with operators, anonymizing customer information, and converting records to Tableau-compatible formats. Students analyzed this dataset during the Tableau analysis competition in weeks 8-10, with outcomes detailed in Section 3.3.

Third, the program implemented student assistants (selected from prior year high performers) and weekly instructor coordination meetings. However, statistical analysis revealed significant grade distribution variations among instructors in 2023 (Kruskal-Wallis test, $p<0.05$, Section 3.2), despite standardized rubrics and coordination efforts. These variations emerged particularly between specific class pairs.

4.2 Assessment Consistency and Student Performance

The statistical analysis of grade distributions revealed complex patterns that merit careful consideration. The emergence of significant differences in assessment outcomes among instructors in 2023, despite standardized rubrics and regular coordination meetings, suggests that achieving complete assessment standardization in multi-instructor environments remains challenging. This finding is consistent with the broader literature on assessment reliability, which indicates that rubrics alone are often insufficient to guarantee inter-rater reliability without complementary measures such as extensive rater training and the use of exemplars [18].

Our analysis of placement test scores provides important context for understanding these assessment variations. The identification of lower academic preparation levels in certain class sections, particularly evident in the 2023 Class E data, suggests that student population characteristics significantly influence learning outcomes and assessment patterns. However, it is crucial to acknowledge that these variations are likely influenced by a combination of confounding factors

beyond student preparedness. Research in higher education has consistently shown that instructor-level variables, such as teaching experience, pedagogical style, and even unconscious biases in grading, can significantly impact assessment outcomes, even within highly structured courses [19] [20]. While this study did not collect data on instructor expertise, the observed variations underscore the importance of considering these factors in future program design and research. This finding emphasizes the need for adaptive teaching strategies that can accommodate diverse student abilities while maintaining consistent academic standards.

4.3 Implications for Data Science Education

The findings of this study have several important implications for the broader field of data science education in higher education. The successful integration of Tableau demonstrates that industry-standard tools can be effectively incorporated into introductory-level courses, even for students with no prior data science experience. This approach is corroborated by other case studies in fields such as accounting [10] and economics [21], which also report positive outcomes when professional-grade software is introduced early in the curriculum. This suggests that concerns about tool complexity, if properly managed through instructional design that considers cognitive load [21], should not deter institutions from adopting professional-grade software in foundational courses.

Furthermore, the program's experience with real-world data analysis projects provides valuable insights into engaging students across different academic disciplines. The high completion rates across various faculties, including both STEM and non-STEM fields, indicate that appropriately structured data science education can successfully serve diverse student populations.

Ultimately, this study provides a practical case study that aligns with national and international frameworks for data science education. A clear indicator of this national alignment is the program's certification under Japan's MDASH [22], where it was also selected as an exemplary 'Plus Program'—a distinction granted to only a select few institutions. The program’s design, which integrates statistical reasoning, computation, and domain context for all students, operationalizes the vision set forth by the National Academies of Sciences, Engineering, and Medicine [23] and aligns with the core competencies, such as 'Analysis and Presentation,' recommended by the [24]. By foregrounding authentic analytic practice, our approach also embodies Donoho's [17] view of data science as the fundamental activity of "learning from data".

4.4 Future Directions and Recommendations

Based on our findings, we propose several recommendations for institutions implementing similar programs. First, the development of real-time assessment monitoring systems could help identify and address grading inconsistencies more promptly. Second, grounded in research on assessment reliability [17], additional instructor training focused specifically on assessment standardization could help reduce grading variations while maintaining appropriate responsiveness to student needs.

Future research should examine the long-term impact of early exposure to professional data analysis tools on students' academic and professional development. Additionally, investigation into the relationship between student characteristics and learning outcomes could help refine teaching strategies for diverse student populations.

4.5 Limitations

Several limitations of this study should be acknowledged. The analysis focuses on a single institution's experience, and while the findings offer valuable insights, their generalizability may be limited by institutional context. Further studies at other institutions are therefore needed to help validate and enhance the generalizability of these findings. Additionally, the two-year study period, while providing substantial data, may not capture longer-term trends in program effectiveness and student outcomes.

These limitations notwithstanding, the study provides important empirical evidence regarding the implementation of comprehensive data science education programs and the challenges of maintaining assessment consistency in multi-instructor environments. The findings contribute significantly to our understanding of how universities can effectively prepare students for an increasingly data-driven world while maintaining academic rigor and educational quality.

5 Conclusion

This study provides significant insights into the implementation of university-wide data science education programs through a comprehensive analysis of Hokuriku University's experience. Addressing our initial research questions, we have identified several key findings that contribute to the broader understanding of data science education in higher education.

In response to our first research question regarding effective implementation of comprehensive data science education, our finding demonstrate that the integration of industry-standard tools like Tableau, combined with real-world data analysis projects, can successfully engage students across diverse academic disciplines. The program's high completion rates across both STEM and non-STEM faculties suggest that appropriate scaffolding and practical application can make data science accessible to all students.

Regarding our second research question about managing multi-instructor assessment consistency, our analysis revealed more complex dynamics than initially anticipated. While standardized rubrics and regular coordination meetings provide essential structure, individual instructor characteristics and student population differences continue to influence assessment outcomes. This finding suggests the need for more sophisticated approaches to maintaining assessment consistency while accommodating diverse student needs.

Our first hypothesis concerning the positive impact of Tableau integration was strongly supported by the data, with high student engagement levels and successful completion of complex analytical projects. However, our second hypothesis regarding assessment standardization was only partially supported, revealing the challenges of maintaining complete consistency in multi-instructor environments.

These findings have significant implications for higher education institutions globally. As universities worldwide respond to the increasing demand for data science education, our study provides empirical evidence for effective program design and implementation strategies. The success of integrating professional-grade analytical tools in introductory courses challenges conventional assumptions about the accessibility of such tools to beginners.

Future research should address several key areas. First, longitudinal studies tracking student outcomes beyond the introductory course would provide valuable insights into the long-term impact of early exposure to professional data analysis tools. Second, investigation of automated assessment systems could help address the challenges of maintaining grading consistency. Finally, cross-institutional studies could help identify how different institutional contexts affect program implementation and outcomes.

In the context of Society 5.0 and increasing digital transformation, the ability to understand and work with data has become crucial across all fields. Our study demonstrates that universities can successfully prepare students for this data-driven future through well-designed, comprehensive programs that balance technical skills with practical application. The challenge going forward will be to continue refining these educational approaches while maintaining consistency and quality across diverse student populations.

The framework and findings presented in this study offer a valuable reference for other institutions developing similar programs. However, success will require ongoing adaptation and refinement based on institutional context, student needs, and evolving technological capabilities. As data science continues to grow in importance across all sectors of society, the effectiveness of foundational education in this field will become increasingly crucial to student success and societal advancement.

Acknowledgement

This work was supported by Hokuriku University Special Research Grant 2023 in Fundamental Research Area and JSPS KAKENHI Grant Number JP23K02558. The authors would like to express their gratitude to the faculty members and student assistants who contributed to the implementation of the Data Science and AI Education Program. Special thanks to Salesforce Japan for providing educational materials and support for the Tableau implementation. We also appreciate the cooperation of campus store and cafeteria operators who provided valuable real-world data for student analysis projects.

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