ORIGINAL ARTICLE

What do the Data Say? A Case Study with Pre-Service Teachers

Safiye Temel-Aslan, Hulya Ertas-Kilic, Melihan Unlu, Betul Keray-Dincel

Aksaray University, Aksaray, Türkiye

***Abstract**: Data literacy, which is considered among 21st century skills, is becoming increasingly important. In particular, incentives for data-driven decision-making draw attention to data literacy. Data literacy is also critical for teachers who need to use data in educational settings. Therefore, there is a need for data on whether teachers are equipped with data literacy competencies before their service. In this study, pre-service teachers' data literacy competencies were examined. The case study approach was used in the study, which was conducted as qualitative research. The study group consisted of 61 pre-service teachers studying in three different undergraduate programs. Data were collected through the "What do the data say?" activity instrument. Rubrics were used to analyze the data. The findings of the study showed that while there was no difference in terms of using data and data communication, there was a statistically significant difference between the programs in terms of data recognition, comparing data and establishing relationships between data competencies, as well as total data literacy. In addition, it was found that the majority of pre-service teachers were partially inadequate or inadequate in terms of using data, data communication and total data literacy. Nearly half of them were partially inadequate or inadequate in comparing data and establishing relationships between data. The results indicated that pre-service teachers have certain deficiencies regarding data literacy.*

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***About the Author**: Safiye Temel-Aslan, Assoc. Prof., Department of Mathematics and Science Education, Faculty of Education, Aksaray University, Aksaray, Türkiye, E-mail: safiye79temel@gmail.com, ORCID: https://orcid.org/0000-0001-6969-8871*

Hulya Ertas-Kilic, Assoc. Prof., Department of Mathematics and Science Education, Faculty of Education, Aksaray University, Aksaray, Türkiye, E-mail: ertashulya@gmail.com, ORCID: https://orcid.org/0000-0001-9683-3186

Melihan Unlu, Assoc. Prof., Department of Mathematics and Science Education, Faculty of Education, Aksaray University, Aksaray, Türkiye, E-mail: melihanunlu@yahoo.com, ORCID: https://orcid.org/0000-0003-3337-8758

Betul Keray-Dincel, Assoc. Prof., Department of Turkish and Social Sciences Education, Aksaray University, Aksaray, Türkiye, E-mail: betulkeraydincel@gmail.com, ORCID: https://orcid.org/0000-0002-2184-7361

***Correspondence to**: Dr. Safiye Temel-Aslan at Aksaray University of Türkiye.*

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Introduction

THE ROLE of data in our lives has increased dramatically over the last two decades. It is estimated that the amount of data generated reaches about 35-40 zettabytes (Çetin & Özkaya, 2019; Erdemir, 2018). The amount of data produced every two days is stated to be greater than that produced from the beginning of time to 2003 (Marr, 2020). Furthermore, the variety and complexity of data have increased compared to the past due to technological advances (Gibson & Mourad, 2018). Apart from its applications in the fields of economics and statistics, data is utilized in all areas of life, from education to health, from the environment to professional working areas and daily life (Fontichiaro et al., 2017). This requires individuals to analyze, interpret, and manage data, use data when making decisions, collect data when necessary, know the methods of collecting and transmitting data, and think based on data to solve problems. For this reason, being data literate is necessary. In the 21st century, data literacy is considered among the important skills and the understanding of its importance is increasing (Fontichiaro et al., 2017; Valencia, 2021).

Data literacy refers to accessing and understanding data; interpreting the information from the data; developing data-driven inferences and explanations; using data as part of evidence-based thinking; evaluating the data critically; formulating and answering problems/questions based on data; using appropriate data, tools, and presentations to support an idea; using data to solve real/authentic problems and communicating solutions; and paying attention to ethical issues when using data (Calzada-Prado & Marzal, 2013; Vahey et al, 2006; Vahey et al., 2012). The framework of data literacy can expand depending on the context. For example, the understanding of data literacy may vary depending on the goals of an individual or organization. The nature of datasets, the intended use of data, and the roles of those who deal with data (e.g., scientists, makers, readers, and communicators) lead to different definitions of data literacy (Wolff et al., 2016). Matthew (2016) points out that the concept of data literacy involves uncertainty and that it would be useful to consider data literacy as a capability. From this perspective, it is possible to talk about data literacy competencies (Wolff et al., 2016).

There are different explanations in the literature on what data literacy competencies are. Data literacy competencies, which are commonly discussed in the aforementioned explanations and need to be used frequently, can be examined as follows: Data recognition, using data, comparing data, data cleaning, selecting data, data source, data quality, data transformation, data collection, data analysis, data presentation, data communication, and data ethics (Temel-Aslan, 2022a; Mandinach et al., 2011; Matthew, 2016). These competencies are introduced below.

Data recognition: Identifying the type of the data (e.g., quantitative or qualitative data) includes being able to determine what the data is about, the context of the data, changes in the data, patterns, and any discrepancies (Hunter-Thomson, 2019; Temel-Aslan, 2022b). Using data: It includes being able to evaluate the data critically; form questions, claims, and arguments based on data; make decisions based on data; use data to support an idea; use data when identifying/presenting a problem/problem or creating a solution to the problem/problem; and being aware of the inference space when using data (Hunter-Thomson, 2020; Matthew, 2016, Temel-Aslan, 2022a). Comparing data: It includes being able to compare two or more groups of data; knowing which methods to use when making comparisons (e.g., arithmetic mean, standard deviation, or proportional reasoning); and reasoning and making inferences based on such comparisons (Reaburn, 2012; Ünlü, 2022). Data cleaning: It involves identifying, correcting, or removing incorrect, corrupt, incorrectly formatted, irrelevant, inconsistent, duplicate, or incomplete data in the dataset (Erwin, 2015; Rahm & Hai Do, 2000). Selecting data: It involves deciding what data is needed to address a particular question or problem (Kjelvik & Schultheis, 2019). Data selection requires identifying the appropriate type and source of the data and the appropriate tools for collecting data (The Office of Research Integrity [ORI], 2021). Data source: It includes being able to determine from which source the data is obtained or will be obtained (e.g., the primary source or secondary source), critically evaluate the data sources, select the correct and reliable ones among the data sources, know the ways to reach the data sources, compare the data from different data sources, and document the sources used (Calzada-Prado & Marzal, 2013; Dong et al., 2009; Rabianski, 2003). Data quality: It includes being able to determine whether the data reflects reality and is reliable, being aware of what information is needed about the quality of the data (for example, data quality dimensions such as accuracy, completeness, and consistency), knowing how to obtain this information, and valuing the data in terms of data quality (DAMA UK Working Group, 2013; Jesilevska, 2017; Shankaranarayan et al., 2003; Wang & Strong, 1996). Data transformation: It includes knowing how to visualize data representations and data; being able to select and use appropriate visualization methods and tools; and being able to convert data from one format (e.g., a table) to another format (e.g., a graphic) (Hunter-Thomson, 2019; Jones et al., 2000). Data collection: It includes being able to collect data and create data, knowing which technology to store and share data and how to use it, obtaining data from sources, evaluating the quality of that data; finding and using purposeful external data repositories; and importing data from data sources (Calzada-Prado & Marzal, 2013; Ertaş-Kılıç, 2022b; Gibson & Mourad, 2018; Nelson, 2015). Data analysis: It includes being familiar with basic data processing, analysis tools, methods, and techniques of the discipline or research area to which the data

relates; understanding the impact of these tools, methods, and techniques on data; being able to select and apply appropriate tools and techniques for data analysis; being able to evaluate the results of the analysis and compare them with other findings; and determining an appropriate workflow for repeated analyses of data (Ertaş-Kılıç, 2022a; Mandinach & Gummer, 2016; Nelson, 2015). Data presentation: It includes being familiar with data presentation methods and tools; being able to plan and implement how the data will be presented in a form that is understandable; being able to evaluate the advantages and disadvantages of different methods of presentation; knowing the general rules of data presentation methods; and being able to recognize errors and gaps in data presentation (In & Lee, 2017; Royal Geographical Society, n.d.; Unwin, 2008). Data communication: It includes knowing the methods and tools of synthesizing, visualizing, and representing data; knowing how to communicate with data (for example, reporting and presenting data); knowing which technology to use to share data and how to use it; explaining the presentation of data in different formats (e.g., table or graphic); understanding how data can be used as evidence during discussion and use (data as evidence); being able to evaluate the strengths, weaknesses, and limitations of the data; understanding and expressing the relationships between data; knowing the tools that can be used to transmit data (e.g., websites [multimedia], short videos, text-based information, comic books, games, or audio stories) (D'Ignazio & Bhargava, 2015; Gibson & Mourad, 2018; Keray-Dinçel, 2022; Maybee & Zilinski, 2015; Sander, 2020). Data ethics: It generally involves collecting, analyzing, storing, sharing, protecting, and using data ethically (Floridi & Taddeo, 2016). Although the boundaries of the competencies described above are unclear, there may be a transition between competencies. Considering competencies in this way can facilitate a better understanding of them. In this study, four competencies that are thought to be more frequently used are included: 'data recognition', 'using data', 'comparing data and establishing relationships between data', and 'data communication'.

Teaching individuals' data literacy competencies is an important expectation for formal education. In the context of education in Türkiye, data literacy is mostly considered either within the scope of information literacy or as a learning area of mathematics (Akcan & Gençyürek-Erdoğan, 2019; Ministry of National Education [MoNE], 2018a; Yabanlı et al., 2013). However, when the scope of data literacy and its widespread use are taken into consideration, the necessity of looking at data literacy with an interdisciplinary understanding emerges. The prediction that data literacy will have a more important role in many professions supports this perspective. For this reason, within the framework of formal education in schools, in addition to teaching the basic contents and experimental methods related to the disciplines, it is also necessary to develop the data literacy competencies of the

students (Schüller, 2020; Temel-Aslan, 2022a). In this development effort, using an interdisciplinary approach is necessary rather than considering it as a learning area of mathematics alone. Although the importance of data literacy is directly or indirectly included in educational programs (MoNE 2018a, 2018b, 2018c), whether an understanding of the subject is reflected in classroom practices needs to be determined.

This study aims to assess some data literacy competencies of pre-service teachers, shedding light on their potential to teach data literacy in the future. It also seeks to reflect on how they can enhance their understanding of teaching and improving data literacy in their classroom practices, as well as the role of their past learning experiences in acquiring and developing data literacy competencies.

Method

In this study, a qualitative research method known as the case study approach was employed to assess the data literacy competencies of pre-service teachers. Case studies aim to provide comprehensive, systematic, and in-depth insights into specific situations of interest (Patton, 2014). This approach places a strong emphasis on examining roles and relationships within a given context, whether it involves an environment, individual, or process as a whole (Yıldırım & Şimşek, 2013). Within the scope of this study, the case study method was utilized to conduct a thorough examination of select data literacy competencies among pre-service teachers. It's important to note that the data collected through the chosen tools were analyzed without seeking generalization.

Participants

The study group, consisting of 61 pre-service teachers, was selected using the convenience sampling method. These pre-service teachers are enrolled at a state university located in the Central Anatolia region of Türkiye. It was determined that the pre-service teachers who participated in the research did not receive any direct training on data literacy before this research. Among these pre-service teachers, 22 of them are studying Science Education, 20 of them are in Turkish Language Education, and 19 are in Mathematics Education programs. PISA (Program for International Student Assessment), an international monitoring research in education, was taken into account in selecting the participants from the specified programs. As it is known, PISA is an international research conducted by OECD (Organisation for Economic Co-Operation and Development) in three-year cycles, evaluating the knowledge and skills acquired by students in the 15-year-old group. In PISA applications, students' reading skills and literacy in mathematics and science

are evaluated (OECD, 2023). When the proficiency levels in the mentioned areas are examined, it is understood that students are expected to be data literate. For example, text types are included when defining different dimensions to measure reading skills. In this context, it is stated that texts may contain lists, tables, graphs, diagrams, advertisements, plans, catalogues, indexes and that such texts require a different reading approach. In addition, the topic of "uncertainty and data" is included in mathematics, and "interpreting data and findings scientifically" in science (MoNE, 2019). Considering these explanations, it can be said that students are expected to develop an understanding of data literacy in all three areas of the PISA research. The role of teachers is important in developing students' data literacy competencies. Within the framework of formal education in Türkiye, teachers who carry out the education and training process at the secondary school level in these fields are selected among the teacher candidates who graduated from mathematics, science, and Turkish Language Education departments. For this reason, teacher candidates studying in the mentioned departments were determined as participants. From this point on, pre-service teachers studying in the Department of Science Education are abbreviated as PST, those studying in the Department of Mathematics Education as PMT, and those studying in the Department of Turkish Language Education are abbreviated as PTLT.

Data Collection Tools

"***What do the Data Say?" Activity Instrument***: The activity instrument, prepared at the undergraduate level, includes the topic of earthquakes. In the introduction section of the instrument organized under the title of "What do the data say?", information was given about earthquakes, one of the natural disasters that take place on Earth. The text includes information about earthquakes, how they occur, and how their magnitudes are measured. In other parts of the activity, data are provided on the earthquakes that took place in 2020 in Türkiye and their immediate surroundings, magnitudes, and distribution according to the month, and questions are asked about this data. The data presented in the table and graph are obtained by Boğaziçi University, Kandilli Observatory, and the Earthquake Research Institute Regional Earthquake-Tsunami Monitoring and Evaluation Center and is publicly available (Kandilli Observatory, and the Earthquake Research Institute, 2021).

There are five stages in the activity. In phase I, the data were presented in tables and there were 12 questions related to this data. In phase II, the data were presented as a graph and eight questions were formed to analyze this data. The questions in phase III were designed to analyze the data presented in tables and graphs in stages I and II together. There were three questions in this stage. In phase IV, the data were presented as a map, one of the data visualization types. This map is the earthquake hazard map of Türkiye

for 2020, created by the Disaster and Emergency Management Presidency [AFAD], (2021). An argument was put forward regarding this map, which was supposedly shared on social media, and students were asked to answer two questions about this argument. In the final phase of the study, pre-service teachers were tasked with adopting the role of a journalist. Specifically, they were required to communicate the information derived from the data regarding the earthquake to their readers. This was to be accomplished by incorporating the tables, graphs, and maps provided in the earlier stages along with informative text. The aforementioned phases aim to determine the main competencies of the pre-service teachers in "recognizing the data, comparing the data, and establishing a relationship between the data, using the data, and data communication" and the sub-competencies given in the table with questions created about the data (data presented in the form of tables, graphs, and maps). In the activity aimed at determining how pre-service teachers perform in the aforementioned data literacy competencies, the competencies to be measured and the questions related to them are given in **Table 1**.

The activity, which was prepared by the researchers, was presented for the opinion of three academicians who are experts in the fields of mathematics, Turkish, and science education. The content of the text and the scope of the questions were re-evaluated and readied for a preliminary study. In the preliminary study, the activity was applied to three pre-service teachers, rearranged with the feedback of the students, and finalized. The main application's data were gathered once, and the activity's implementation took about 90 minutes.

Data Analysis

Scoring the Answers of the Competencies of Recognizing the Data, Comparing the Data, and Establishing Relationships between the Data

In the analysis of the questions designed to assess competencies related to data recognition, data comparison, and data relationship establishment (questions in phases I, II, III, and IV), responses were scored on a scale of 0 to 3. The scores and criteria for evaluating the questions are given in **Table 2**.

After all of the questions had been scored, the data was re-evaluated by a different researcher to ensure consistency, and the intraclass correlation coefficient was used to determine the degree of agreement between the as-

Table 1. The Competencies Assessed by the Activity and the Corresponding Questions.

Competencies to be measured by the activity	
Recognizing data	a) Recognize data presented in tabular form (Phase I: Questions 1, 2, 3)
	b) Recognizing graphically presented data (Phase II: Questions 1, 2, 3)
Comparing data and establishing relationships between data	a) Comparing the data presented in tabular form and establishing a relationship between the data (Phase I: Questions 4, 5, 6, 7, 8, 9, 10, 11)
	b) Comparing data presented graphically and establishing a relationship between data (Phase II: Questions 4, 5, 6, 7)
	c) Comparing data presented in different formats (Phase II: Question 8)
Using data	a) Generating data-based claim (Phase III: Question 1)
	b) Evaluate the claim generated based on data (Phase I: Question 12; Phase III: Question 2)
	c) Identify data associated with the claim (Phase III: Question 3)
	d) Generating arguments based on data (Phase IV: Question 2)
	e) Evaluate the argument generated based on the data (Phase IV: Question 1)
Data communication	a) When creating the text, provide all relevant or requested data (Phase V: Question 1)
	b) Specify the data source when creating the text (Phase V: Question 1)
	c) Include relationships/comparisons between data when creating text (Phase V: Question 1)
	d) To be able to express what the data says when creating the text (to be able to identify the area of inference) (Phase V: Question 1)
	e) Creating a data-driven argument while creating the text (Phase V: Question 1)
	f) Distinguish between data and opinions when creating the text (Phase V: Question 1)
	g) Organization of knowledge (Phase V: Question 1)

Table 2. Evaluation Criteria and Scoring for Answers.

	Criteria	Scoring
Incorrect	Unacceptable (All explanations are incorrect, unacceptable, or without an answer.)	0
Partially incorrect (errors are in the majority)	Partially acceptable However, the majority of responses contain errors (The explanations contain accurate and acceptable parts, but they also contain incomplete parts).	1
Partially correct (rights are in the majority)	Partially acceptable However, there are deficiencies (The explanations are accurate and acceptable, but they have deficiencies).	2
Correct	Acceptable (All explanations are true and acceptable.)	3

Table 3. Intraclass Correlation Coefficients between Raters for Competencies and Total Data Literacy.

Competencies	Assessors	n	$\bar{X}$	ss	r_{xy}
Recognizing data	1	61	11.28	3.19	0.941
	2	61	11.31	3.06	
Using data	1	61	6.84	2.89	0.930
	2	61	6.31	2.67	
Comparing data and establishing relationships between data	1	61	19.70	4.76	0.921
	2	61	19.59	4.95	
Data communication	1	61	8.13	4.95	0.898
	2	61	4.51	3.25	
Total data literacy	1	61	45.98	10.81	0.935
	2	61	41.72	9.38	

Table 4. Level Scores According to Data Literacy and Sub-Competencies.

Competencies	Max. points	Min. points	Inadequate	Partially inad-equate	Partially adequate	Adequate
Recognizing Data	18.00	0.00	0.00-4.49	4.50-8.99	9.00-13.49	13.50-18.00
Using Data	18.00	0.00	0.00-4.49	4.50-8.99	9.00-13.49	13.50-18.00
Comparing Data and Establishing Relationships between Data	39.00	0.00	0.00-9.74	9.75-19.49	19.50-29.24	29.25-39.00
Data Communication	21.00	0.00	0.00-5.24	5.25-10.49	10.50-15.74	15.75-21.00
Total Data Literacy	96.00	0.00	0.00-23.99	24.00-47.99	48.00-71.99	72.00-96.00

sessors (see **Table 3**). Consensus was achieved among the assessors' regarding the scores they assigned.

Scoring the Answers for Data Communication Competency

The data of the answers in phase V within the scope of data communication competency of the pre-service teachers participating in the research were evaluated using an analytical rubric. The rubric used was developed by determining the issues to be considered when sharing data and creating an informative text based on the data by examining the literature on data commu-

nication. The rubric consists of seven criteria and four grades. The lowest score that can be obtained from the rubric is 0 while the highest is 21. Data communication competency was assessed according to the total score obtained from the rubric. The rubric was examined by three academicians working in the fields of science, Turkish, and mathematics education. After the necessary edits and corrections were made, the rubric was used for data analysis.

Reliability

To ensure reliability during the scoring of the rubric, two different raters scored the answers, and agreement between them was calculated using the intraclass correlation coefficient. This statistic was preferred because it allows determining the interrater reliability coefficient based on both competencies and the total score (Kutlu et al., 2010). A common opinion of the raters was obtained on the different scores given by them. The intraclass correlation coefficients demonstrating alignment between raters regarding competencies and total data literacy are presented in **Table 3**.

According to **Table 3**, the interrater reliability coefficients are above .89 for competencies and total data literacy. This value shows that the agreement between the assessors and the reliability of the results are high (Howell, 1997; Kutlu et al., 2010; Şencan, 2005).

Analyzing Data Related to Data Literacy Competencies

In the study, the total scores for each of the competencies measured under the scope of data literacy, as well as the 'total data literacy' score derived from the sum of these competency scores, were analyzed. As the scores did not show normal distribution for all three sections and the group sizes were less than 30, non-parametric statistics were used to analyze the data (Büyüköztürk, 2012; Evrekli et al., 2011). As the number of groups was 3, the Kruskal–Wallis H test for unrelated measurements was applied.

To better understand pre-service teachers' data literacy status, each data literacy competency score and the total data literacy score were divided into four equivalent score intervals. Since the rubrics were structured in four grades, four score ranges were determined (Özçakır-Sümen & Çalışıcı, 2019). The level for each score range is defined. Thus, pre-service teachers were divided into level groups according to the scores they obtained from the relevant competency. The findings are presented in graphs. Table 4 shows the maximum and minimum scores that can be obtained from data literacy, competencies, and the level groups according to the scores.

The level groups in **Table 4** are determined as inadequate, partly inadequate, partly adequate, and adequate. Inadequate refers to either com-

pletely or substantially incorrect answers to questions about data literacy; partially inadequate refers to answering questions about data literacy in such a way that errors are in the majority; partially adequate refers to answering questions about data literacy in such a way that corrects are in the majority; adequate level refers to answering questions about data literacy either completely or largely correctly.

Research Ethics

Participants were informed about the purpose of the research and their rights in the research. They were also notified that they had the freedom to withdraw from the study at any point, without providing a reason, and without facing any difficulties. The data were securely stored, analyzed with strict confidentiality, and reported anonymously. Furthermore, in accordance with ethical regulations, approval for this study was obtained from the Human Research Ethics Committee of the university to which the authors are affiliated.

Results

This section presents descriptive and inferential statistical findings. The results of the descriptive analysis of data literacy of pre-service teachers according to departments are given in **Table 5**.

According to Table 5, the averages of the total data literacy scores of PST ($\bar{X}$ = 47.86) and PMT ($\bar{X}$ = 48.47) are similar to each other. The mean score of data literacy for PTLT ($\bar{X}$ = 39.55) is lower than other departments. Descriptive analysis results for data literacy competencies are presented in Table 6.

According to **Table 6**, the mean scores of PST and PMT are similar to each other in the competencies of recognizing and using data among the data literacy competencies of pre-service teachers. The average scores of PTLT's competencies for recognizing the data, comparing the data, and establishing relationships between the data are low compared to the other departments. Conversely, the average score of PTLT's competence in using the data is higher than the other departments. In data communication competency, the averages of PST, PMT, and PTLT differ slightly from each other.

The Kruskal–Wallis H test results for pre-service teachers' total data literacy and data literacy competencies by departments are presented in **Table 7**.

As per **Table 7**, the scores of pre-service teachers on data recognition competency differ significantly according to the departments (χ^2 [SD = 2, n

Table 5. Descriptive Analysis Results for Total Data Literacy Scores of Pre-Service Teachers by Departments.

Departments	n	Max.	Min.	$\bar{X}$	ss
PST	22	62	24	47.86	9.30
PMT	19	71	22	48.47	12.06
PTLT	20	53	17	39.55	9.58

Table 6. Descriptive Analysis Results of Pre-Service Teachers' Data Literacy Competency Scores by Departments.

Data Literacy Competencies	Departments	N	Max.	Min.	$\bar{X}$	ss
Recognizing data	PST	22	18	7	12.27	2.51
	PMT	19	18	7	12.79	3.03
	PTLT	20	13	1	8.00	3.08
	Total	61	18	1	11.03	3.54
Comparing data and establishing relationships between data	PST	22	31	13	22.27	4.30
	PMT	19	27	14	21.16	3.99
	PTLT	20	25	6	16.85	4.88
	Total	61	31	6	20.15	4.94
Using data	PST	22	14	2	6.32	2.34
	PMT	19	11	0	6.47	2.99
	PTLT	20	12	0	7.20	2.93
	Total	61	14	0	6.66	2.73
Data communication	PST	22	14	0	7.00	5.18
	PMT	19	18	1	8.05	4.92
	PTLT	20	16	0	7.50	4.65
	Total	61	18	0	7.49	4.87

Table 7. Kruskal-Wallis H Test Results of Data Literacy Competencies and Total Data Literacy by Departments.

Competencies	Departments	n	Row average	sd	$\chi 2$	p	Difference
Recognizing data	PST	22	37.09	2	16.90	0.000*	PST-PTLT, PMT-PTLT
	PMT	19	39.68				
	PTLT	20	16.05				
Comparing data and establishing relationships between data	PST	22	38.05	2	8.50	0.002*	PST-PTLT, PMT-PTLT
	PMT	19	34.74				
	PTLT	20	19.70				
Using data	PST	22	27.73	2	1.56	0.368	
	PMT	19	30.24				
	PTLT	20	35.33				
Data communication	PST	22	28.84	2	1.19	0.716	
	PMT	19	33.37				
	PTLT	20	31.13				
Total data literacy	PST	22	35.48	2	4.39	0.016*	PST-PTLT, PMT-PTLT
	PMT	19	35.66				
	PTLT	20	21.65				

= 61] = 16.90, $p < 0.05$). When the order averages are taken into consideration, the scores of PMT for the competency of recognizing the data are the highest among the departments, followed by PST and PTLT. The competency scores of PMT and PST in recognizing the data did not significantly differ, but there was a significant difference between the scores of pre-service teachers in these two departments and those obtained by PTLT. When the scores of pre-service teachers on the competency of comparing data and establishing relationships between data are compared, a significant difference according to the departments is observed (χ^2 [SD = 2, n = 61] = 8.50, $p < 0.05$). Considering the order of averages, PST obtains the highest score in the competency of comparing and establishing relationships between data, followed by PMT and then PTLT. While there was no significant difference between the scores obtained by PMT and PST from the competency of comparing the data and establishing a relationship between the data, the difference between the scores received by the pre-service teachers of these two departments and those obtained by PTLT was significant. The scores of pre-service teachers in data use and data communication competencies did not significantly differ among the departments.

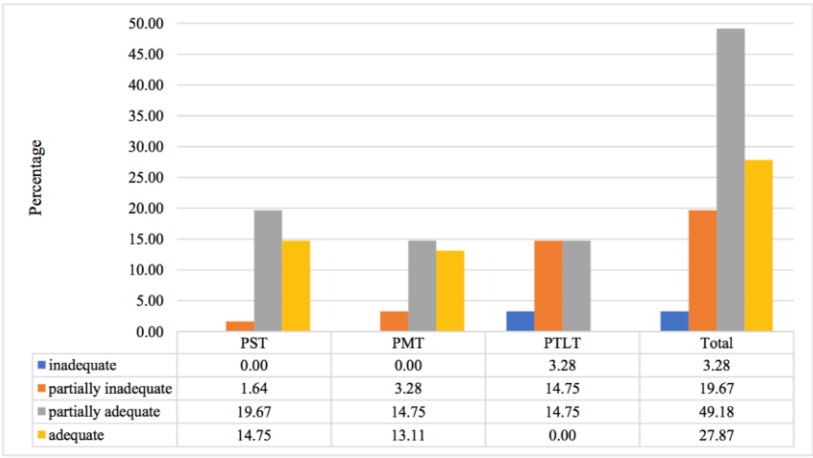
The results of the analysis show that the total data literacy scores of pre-service teachers differ significantly by departments (χ^2 [SD = 2, n = 61] = 4.39, $p < 0.05$). When the order averages are taken into consideration, the total data literacy scores of PMT are the highest among the departments, followed by PST and then PTLT. While there was no significant difference between the data literacy scores of PMT and PST, the difference between the scores of the pre-service teachers of these two departments and those of PTLT was significant.

Level Groups Determined According to the Scores of Pre-Service Teachers from the Data Literacy Competencies and Total Data Literacy

Level Groups for the Competency of Recognizing Data

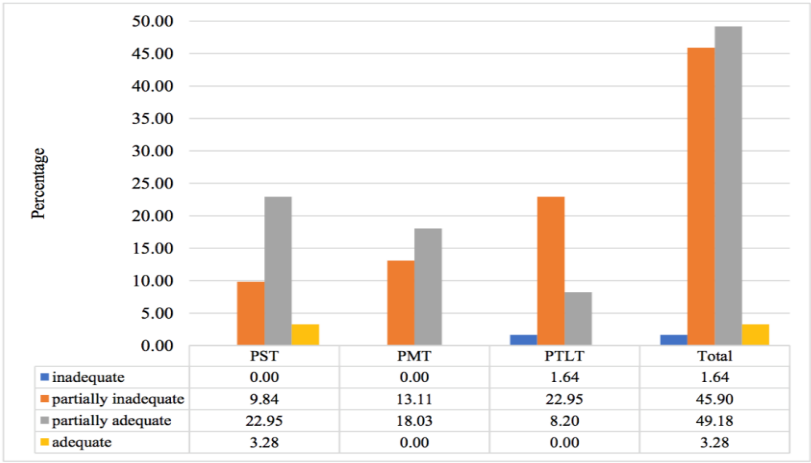
The results pertaining to the level groups established based on pre-service teachers' scores in data recognition competency are presented in **Figure 1**.

According to Figure 1, 3.3% (n = 2) of the pre-service teachers were at the "inadequate" level in terms of data recognition competency and both these pre-service teachers were PTLT. Meanwhile, 19.7% of the pre-service teachers were at the "partially inadequate" level. Of these pre-service teachers, 1.6% (n = 1) were PST, 3.3% (n = 2) were PMT, and 14.8% (n = 9) were PTLT. Furthermore, 49.2% (n = 30) of the pre-service teachers are at the "partially adequate" level. Of these pre-service teachers, 19.7% (n = 12)



	PST	PMT	PTLT	Total
inadequate	0.00	0.00	3.28	3.28
partially inadequate	1.64	3.28	14.75	19.67
partially adequate	19.67	14.75	14.75	49.18
adequate	14.75	13.11	0.00	27.87

Figure 1. The Levels of Pre-Service Teachers According to the Competency Score of Recognizing Data by Departments



	PST	PMT	PTLT	Total
inadequate	0.00	0.00	1.64	1.64
partially inadequate	9.84	13.11	22.95	45.90
partially adequate	22.95	18.03	8.20	49.18
adequate	3.28	0.00	0.00	3.28

Figure 2. The Levels of Pre-Service Teachers According to the Competency Score of Comparing Data and Establishing Relationships between Data by Departments.

were PST, 14.8% (n = 9) were PMT, and 14.8% (n = 9) were PTLT. Finally, 27.9% (n = 17) of the pre-service teachers were at the "adequate" level. Of the pre-service teachers at this level, 14.8% (n = 9) were PST and 13.1% (n = 8) were PMT. There is no PTLT at this level.

Level Groups for the Competency of Comparing Data and Establishing Relationships between Data

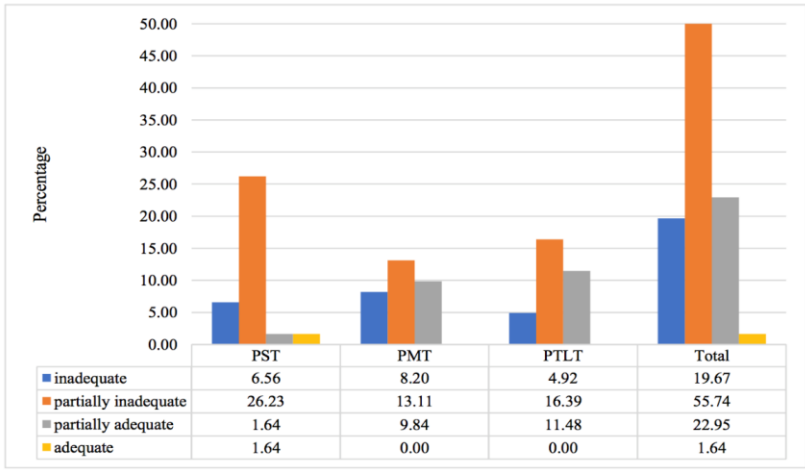
The findings regarding the level groups determined according to the scores of the pre-service teachers in the competency of comparing data and establishing relationships between data are given in **Figure 2**.

According to **Figure 2**, 1.6% (n = 1) of the pre-service teachers were at the "inadequate" level in terms of the competency of comparing data and establishing relationships between data, and they are PTLT. In addition, 45.9% (n = 28) of the pre-service teachers were at the "partially inadequate" level. Of these pre-service teachers, 9.8% (n = 6) were PST, 13.1% (n = 8) were PMT, and 23% (n = 14) were PTLT. Further, 49.2% (n = 30) of the pre-service teachers are at the "partially adequate" level. Of these pre-service teachers, 23% (n = 14) were PST, 18% (n = 11) were PMT, and 8.2% (n = 5) were PTLT. Finally, 3.3% (n = 2) of the pre-service teachers were at the "adequate" level. Both the pre-service teachers at the proficient level were PST. There was no pre-service teacher at this level from the other departments.

Level Groups for the Competency of Using Data

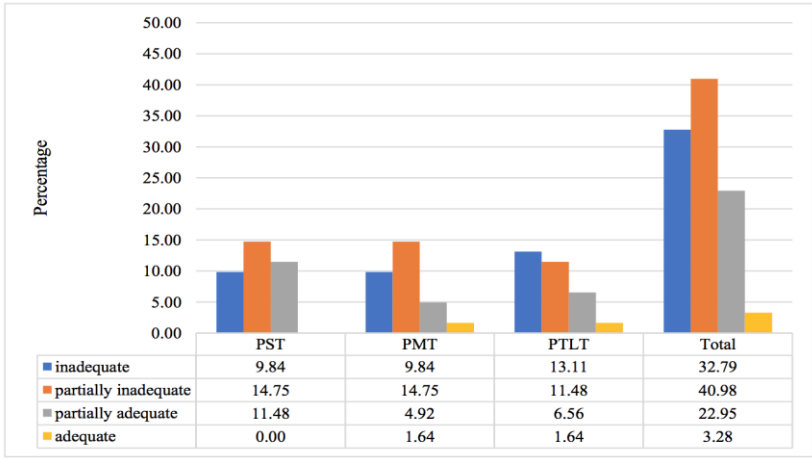
The findings regarding the level groups determined according to the scores of the pre-service teachers on the competency of using data are given in **Figure 3**.

As per **Figure 3**, 19.7% (n = 12) of the pre-service teachers were at the "inadequate" level in terms of competence in using data. Of these pre-service teachers, 6.6% (n = 4) were PST, 8.2% (n = 5) were PMT, and 4.9% (n = 3) were PTLT. Meanwhile, 55.7% (n = 34) of the pre-service teachers were at the "partially inadequate" level. Of these pre-service teachers, 26.2% (n = 16) were PST, 13.1% (n = 8) were PMT, and 16.4% (n = 10) were PTLT. Further, 23% (n = 14) of the pre-service teachers were at the "partially adequate" level. Of these pre-service teachers, 1.6% (n = 1) were PST, 9.8% (n = 6) were PMT, and 11.5% (n = 7) were PTLT. Finally, 1.6% (n = 1) of the pre-service teachers were at the "adequate" level. The pre-service teacher at the proficient level was PST. There was no pre-service teacher at this level from the other departments.



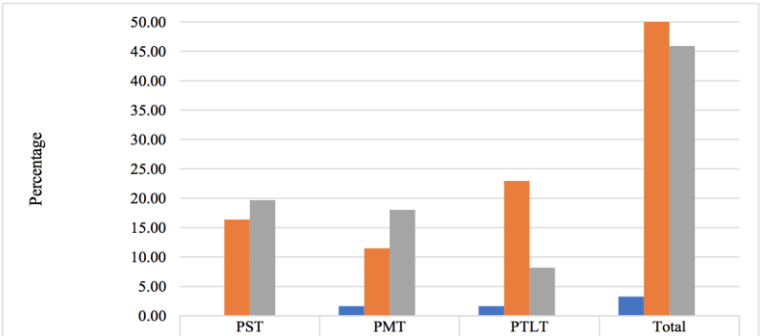
	PST	PMT	PTLT	Total
inadequate	6.56	8.20	4.92	19.67
partially inadequate	26.23	13.11	16.39	55.74
partially adequate	1.64	9.84	11.48	22.95
adequate	1.64	0.00	0.00	1.64

Figure 3. The Levels of Pre-Service Teachers According to the Competency Score of Using Data by Departments.



	PST	PMT	PTLT	Total
inadequate	9.84	9.84	13.11	32.79
partially inadequate	14.75	14.75	11.48	40.98
partially adequate	11.48	4.92	6.56	22.95
adequate	0.00	1.64	1.64	3.28

Figure 4. The Levels of Pre-Service Teachers According to Their Data Communication Competency Scores by Departments.



	PST	PMT	PTLT	Total
inadequate	0.00	1.64	1.64	3.28
partially inadequate	16.39	11.48	22.95	50.82
partially adequate	19.67	18.03	8.20	45.90
adequate	0.00	0.00	0.00	0.00

Figure 5. Pre-Service Teachers' Levels Determined According to Their Total Data Literacy Scores.

Level Groups for Data Communication Competency

The findings regarding the level groups determined according to the scores of pre-service teachers on data communication competency are given in **Figure 4**.

According to **Figure 4**, 32.8% (n = 20) of the pre-service teachers were at the "inadequate" level in terms of data communication competency. Of these pre-service teachers, 9.8% (n = 6) were PST, 9.8% (n = 6) were PMT, and 13.1% (n = 8) were PTLT. Meanwhile, 41% (n = 25) of the pre-service teachers are at the "partially inadequate" level. Of these pre-service teachers, 14.8% (n = 9) were PST, 14.8% (n = 9) were PMT, and 11.5% (n = 7) were PTLT. Further, 23% (n = 14) of the pre-service teachers were at the "partially adequate" level. Of these pre-service teachers, 11.5% (n = 7) were PST, 4.9% (n = 3) were PMT, and 6.6% (n = 4) were PTLT. Finally, 3.3% (n = 2) of the pre-service teachers were at the "adequate" level. Of the pre-service teachers at this level, 1.6% (n = 1) were PMT and 1.6% (n = 1) were PTLT. There were no pre-service teachers at this level in PST.

Level Groups for Total Data Literacy

The findings regarding the level groups determined according to the total data literacy scores of pre-service teachers are given in **Figure 5**.

According to **Figure 5**, 3.3% (n = 2) of the teachers were "inadequate," 50.8% (n = 31) were "partially inadequate," and 45.9% (n = 28) were

"partially adequate" in terms of general data literacy. There was no pre-service teacher who could be evaluated at the "adequate" level. While there was no PST with "inadequate" data literacy level, there was one (1.6%) pre-service teacher in PMT and one in PTLT. Of the teacher candidates whose data literacy level was "partially inadequate," 16.4% (n = 10) were PST, 11.5% (n = 7) were PMT, and 23% (n = 14) were PTLT; and 19.7% (n = 12) of the pre-service teachers at the "partially adequate" level were PST, 18% (n = 11) were PMT, and 8.2% (n = 5) were PTLT.

Discussion and Conclusion

In this study, the status of PST, PMT, and PTLT in terms of total data literacy with some data literacy competencies (assessed by the sum of the scores obtained from these competencies) were determined. The scores obtained by the pre-service teachers in the competencies of recognizing, comparing, and establishing a relationship between the data among the data literacy competencies included in the study significantly varied across departments. This difference was observed between PMT and PTLT (in favor of PMT) and PST and PTLT (in favor of PST) but not between PMT and PST. In terms of using data and data communication competencies, the scores received by the pre-service teachers did not significantly differ according to the departments (**Table 7**). The results of the study show that the total data literacy scores of pre-service teachers significantly differ according to the departments. Accordingly, when PMT and PST were compared in terms of total data literacy score, the average score of PMT was higher but the difference between them was not significant, PTLT had the lowest average score, and a significant difference existed between the scores of PMT and PST and those of PTLT (see **Table 5** and **Table 7**).

In light of the findings above, it can be inferred that the differences between PTLT, PST, and PMT in favor of the latter two are due to these departments being reinforced with data (e.g., laboratory courses for PST and basic mathematics for PMT), surveys and measurement results (e.g., Research Methods in Education), and graphics or tables (e.g., Chemistry I and Physics I for PST; Analysis I and Statistics for PMT). This suggests that PTLT remains behind PST and PMT in offering data-rich learning environments where the students' data literacy can be improved, albeit to a limited extent. In other words, there are differences in the nature of the subjects that pre-service teachers study and learn. It can be said that PST and PMT are more interested in data due to the experimental and mathematical nature of their subjects (Merk et al., 2020, Zeuch et al., 2017).

To better understand the data literacy status of pre-service teachers, their competency scores were also analyzed from a different perspective, in which level groups were identified. The findings regarding the level groups

showed that more than half the pre-service teachers were partially inadequate (50.8%) or inadequate (3.3%) in terms of total data literacy; the rest were partially adequate (45.9%), and there was no pre-service teacher who could be considered adequate. The findings indicate that PTLT has the lowest level of data literacy in terms of the determined levels among the departments. When evaluated in terms of data literacy competencies, the majority of pre-service teachers are partially adequate (49.2%) or adequate (27.9%) in data recognition competency. The levels of PST and PMT are close to each other, and the lowest level is seen in PTLT. In terms of the competency of comparing data and establishing relationships between data, approximately half of the pre-service teachers were partially adequate (49.2%) or adequate (3.0%); while the other half was approximately partially inadequate (45.9%) or inadequate (1.6%). In this competency, the proficiency level of PST is higher, followed by PMT, and the level of the PTLT is remarkably low. This is also seen in results of the Kruskal–Wallis H test, which indicate that the scores obtained from the competency of comparing data and establishing relationships between data differ significantly among the departments and that this differentiation is between PST-PTLT and PMT-PTLT. In terms of competency in using data, the majority of pre-service teachers were partially inadequate (55.7%) or inadequate (19.7%). In this competency, the proficiency levels of PTLT and PMT are similar and significantly higher than PST. However, the Kruskal–Wallis H test result of the scores obtained from the competency of using data showed no significant difference according to the departments. However, the assessment of the level of competency shows that the vast majority of PST is partially inadequate or inadequate. In terms of data communication competency, the majority of pre-service teachers are partially inadequate (41.0%) or inadequate (32.8%). The findings suggest that pre-service teachers of all three departments are at a similar level in terms of data communication competency.

When the findings are evaluated in general, the majority of pre-service teachers are partially adequate or adequate in terms of data recognition competency; approximately half of them are partially adequate or adequate in terms of comparing data and establishing relationships between data; and the majority are partially inadequate or inadequate in terms of using data and data communication. In terms of total data literacy, more than half of the pre-service teachers are partially inadequate or inadequate. Descriptive statistical results also show that the average of the total data literacy scores received by the pre-service teachers corresponds to about half or less of the highest score that can be obtained. Therefore, the findings reveal that pre-service teachers have deficiencies in data literacy, indicating that the contributions of pre-service teachers' past learning experiences in their acquisition and development of data literacy competencies are quite limited. The Teacher Education Ministerial Advisory Group report prepared in 2014 also sup-

ports this conclusion. The report draws attention to the lack of teacher candidates in higher education that possess the knowledge and skills to use data to inform and improve their teaching practices and recommends that teacher candidates be equipped with the skills to collect and analyze data to assess students' learning needs and guide the learning process (Craven et al. 2014).

It is conceivable that the data literacy deficiencies identified among pre-service teachers, as highlighted by the aforementioned findings, could have an impact on classroom instruction. Shreiner and Dykes (2021) concluded in their study that the majority of social studies teachers who participated in their study did not include data literacy practices in their lessons. Some studies also point out that teachers have difficulties in using and interpreting data (Cowie & Cooper, 2016; Gelderblom et al, 2016; Zapata-Rivera et al., 2016). Teachers are expected to use data for teaching purposes in their decision-making processes and when designing their lessons. However, it is stated in the literature that especially pre-service teachers have deficiencies in data literacy (DeLuca & Bellara, 2013; Piro & Hutchinson, 2014). For example, Dunlap and Piro (2016) stated that all of the participants (pre-service teachers) who examined the sample data sets they obtained about schools expressed discomfort in understanding the data, and they expressed this as "I knew nothing about data or what it was", "I didn't know what constituted data. I also didn't know you could read data.", and "I had no ideas about what the numbers meant or really that I needed to be concerned [with the data]." In the literature, some studies address data used in different contexts. McDowall et al. (2021) examined pre-service teachers' uses of data to inform and evaluate their teaching practice and found that while some pre-service teachers demonstrated many of the skills related to data use, others needed support. Although the context for assessing data literacy in this study (data from a natural phenomenon) is different from the context of the studies mentioned above (student data), similar results are pointed to.

Data literacy, which is considered a 21st-century skill, is seen as an important skill that individuals require for success, especially in the current competitive business environment (Valencia, 2021). For this reason, studies and incentives for the development of data literacy within the framework of formal education have increased in recent years (Wolff et al., 2019). Teachers have a key role in improving students' data literacy in schools. Therefore, first of all, teachers are expected to be data literate. Nevertheless, the findings from this study indicate that the participating pre-service teachers exhibit deficiencies in certain data literacy competencies. In line with these findings, teacher candidates need learning experiences that will support data literacy. The findings of the study support the calls in the literature to improve data literacy in pre-service teacher education (Mandinach & Gummer, 2013; Miller-Bains et al., 2022; Reeves, 2017; Reeves & Honig, 2015). This is because it may be later for teachers to learn data literacy competencies while

on the job than when they are still pre-service teachers (Mandinach & Jimerson, 2016). Learning environments to support more data literacy should be offered in teacher education such that pre-service teachers can use data when making and communicating decisions about their teaching processes when they begin in their profession (Mandinach & Gummer, 2013) and support their students in being data literate.

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