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Table of Contents

Teaching and Assessing Data Literacy: Resource Guide for Supporting Pre-Service and In-Service Teachers

Purpose: The *Teaching and Assessing Data Literacy: Resource Guide for Supporting Pre-Service and In-Service Teachers* is intended to support the work of instructors in developing data literacy learning objectives, instruction, and measures.

Audience: Teacher preparation faculty; local education agencies providing professional development for in-service teachers; state education agencies setting expectations and reviewing teacher preparation programs; national educator preparation accreditation agencies articulating standards and reviewing teacher preparation programs

Introduction

More than ever before, teachers are being asked to use academic and non-academic student data to inform their instructional decisions. We are far from the time of a simple assessment cycle based on discrete tasks that serve to inform grading. On an almost daily basis, teachers collect, analyze, interpret, and use data from a myriad of sources including standardized assessments, curriculum-based benchmark measures, and non-academic data such as attendance or disciplinary action information. The results are used to make a variety of instructional decisions (e.g., setting student learning goals; documenting progress on goals; creating learning groups; differentiating instruction; providing evidence-based feedback to students and parents).

Yet only a fraction of teacher preparation providers say they provide comprehensive training in using data for teaching, and the effectiveness of the training provided is unknown (Mandinach, Gummer, & Friedman, 2013). As a result, it is unclear whether teacher candidates are developing the data literacy knowledge and skills necessary to positively affect student learning. In 2014, the Data Quality Campaign (DQC; see https://dataqualitycampaign.org/) published a recommendation to states to include data literacy skills in their teacher licensure policies. Additionally, the DQC has defined data literacy for a variety of education audiences including state education agencies, educators, and the teacher preparation field. The DQC has released multiple resources to guide the work of educators; relevant data literacy instructional resources from DQC are included in Appendix A.

Mandinach and Gummer (2016) provide evidence-based suggestions on how teacher preparation programs (and in-service teacher professional development programs) can incorporate data literacy knowledge and skills. At the start of teacher preparation programs, foundational data literacy knowledge should be taught. Topics should include that data can be gathered through multiple academic and non-academic sources, as well as discussions of ethical uses of data. Following the introduction of foundational knowledge, data literacy can then be threaded throughout programs of study, including opportunities in field experiences where pre-service teachers may be able to work with students, collect student data, and then work with a mentor teacher to interpret the results. Additionally, addressing culturally responsive practices

related to assessments and other data collection instruments, as well as providing technology instruction related to data literacy (e.g., skills related to the use of data dashboards, data systems, spreadsheet functions, etc.) are critical. The authors suggest an integrated approach to learning about data literacy rather than a stand-alone course. However, they acknowledge a stand-alone course offering can provide an opportunity for a "deeper dive."

Additionally, Salmacia (2017) conducted a qualitative case study that provides information to higher education institutions regarding the foundational content pre-service teachers need. The purpose of the study was "to help teacher training organizations identify approaches for teaching data literacy by sharing promising practices and lessons learned from organizations that have pioneered this work over the last several years" (p. iii). Based on interviews of faculty members and teachers, Salmacia (2017) found agreement or strong agreement that a critical aspect of being a successful teacher is being data-literate. Further, the "majority of teachers interviewed thought that data literacy skills were some of the most important that a teacher could possess [... and] becoming an outcome-driven, data-literate teacher was absolutely necessary [...]" (p. 140). These findings underscore the need for data literate teachers to assist all learners in attaining content knowledge and acquisition of skills. Using data to inform individual and group instruction increases the opportunities for growth.

According to a recent National Center for Education Evaluation and Regional Assistance review of 23 studies meeting rigorous standards of evidence, teachers' use of formative assessment has been shown to have a significant and positive effect on student learning in mathematics, reading, and writing (Klute, Apthorp, Harlacher, & Reale, 2017). Results such as these demonstrate a clear need for teacher preparation programs to provide instruction and authentic experience related to data literacy knowledge and skills.

Method

A systematic literature review was conducted on the topic of pre-service and early in-service teachers' data literacy knowledge and skills. The researchers sought to define what pre-service and early in-service teachers need to know and be able to do with data to be successful in their first few years of teaching. Data are defined as academic and non-academic sources of information.

Multiple research questions guided the systematic literature review including:

- What are the existing definitions/frameworks for data literacy?
- What instructional resources exist to teach data literacy?
- What instruments exist to measure teachers' data literacy?

The following tables presents the keywords for skill and population used for the literature search:

Keywords for skill
Data literacy
Data literate
Assessment literacy
Assessment literate
Data collection
Data analysis
Statistical literacy
Assessment competence

Keywords for population
Pre-service
Pre-service teacher education
Teacher education
Student teacher
Student teachers
Teacher education program
Teacher preparation program
Teacher training
Teacher preparation
Educator preparation

As noted in the table above, the keyword search included assessment literacy and statistical literacy as well as data literacy. Assessment literacy publications were reviewed as part of the systematic literature review. Data literacy is often confused with assessment literacy, and assessment literacy is typically viewed as a subset of data literacy. Assessment literacy is defined as involving the understanding of assessment principles and generally refers to traditional, standardized assessments (Mertler & Campbell, 2005). As a result, the researchers intentionally focused this *Resource Guide* on the topics of data literacy, statistical literacy, and graph literacy.

The following databases were searched for the purposes of the systematic literature review:

- Education Full Text (H. W. Wilson)
- Education Abstracts (H. W. Wilson)
- ERIC (Education Resources Information Center)
- Sage Journals
- Scopus
- Quick Search
- Web of Science
- Science Direct

Additionally, recommendations from experts in the field were reviewed and relevant references cited in publications identified through the literature search were also included.

The eligibility criteria for the systematic literature review included:

- ***Year of publication*:** Publications issued in 2009 through 2019 were eligible. This 10-year period was chosen based on the U.S. Department of Education report entitled *Implementing Data-Informed Decision Making in Schools-Teacher Access, Supports and Use* that was published in 2009.
- ***Types of publications:*** The research team reviewed journal articles, reports, instructional resources, book chapters, and/or dissertations that were published (or available) in English.
- ***Target population:*** The publications had to involve PK-12 pre-/in-service teachers.

- ***Topics:*** The publications had to examine one or more of the following: the definition(s) and/or framework(s) of data literacy; learning outcomes for data literacy; instructional resources to teach data literacy; and/or instruments used to measure data literacy.

The processes followed for determining if publications should be included in the systematic literature review were:

- ***Stage 1: Screening:*** Publications that were returned based on the keyword searches noted above were filtered for eligibility based on publication type, year, and if the publication was available in English.
- ***Stage 2: Screening:*** For the publications meeting eligibility based on the Stage 1 Screening process, the researchers reviewed the publication's title and abstract to determine if it addressed one or more of the research question topics and if the publication was related to teacher preparation or professional development for PK-12 teachers.
- ***Stage 3: Coding:***
    - ***Phase 1: Analysis and Categorization of Publications by Topic Area:*** During the first phase of coding, researchers reviewed the full publication and determined the type of publication, target population, and categorized the publication in relation to the research questions. Next, the researchers determined if the publication should be moved to the second coding phase and noted a rationale for the determination.
    - ***Phase 2: Identification and Synthesis of Themes:*** Next, the researchers divided into three teams. Team 1 reviewed publications categorized as providing information regarding definitions, learning outcomes, and frameworks. Team 2 reviewed publications categorized as providing information regarding instructional resources, and Team 3 reviewed publications categorized as addressing or including measures. Each team identified key themes, resources, and measures from the publications, and then synthesized the findings.

This *Resource Guide* represents the results of the synthesis of key themes, resources, and measures.

Application of Resources

How to teach data literacy to pre-service teachers has not received significant attention in the literature. Through this *Resource Guide*, the authors explore definitions, learning outcomes, and frameworks for data literacy and the associated topics of statistical literacy and graph literacy. It also provides an overview of instructional resources for teaching data literacy and statistical literacy as well as measures for assessing data literacy, statistical literacy, and graph literacy knowledge and skills.

The resources presented in this guide are intended to support teacher preparation faculty and teacher professional development instructors in:

- Understanding data literacy definitions and frameworks;

- Identifying data literacy learning outcomes;
- Developing learning objectives;
- Conducting reviews of curriculum and courses to determine alignment to data literacy, statistical literacy, and graph literacy foundational knowledge and learning outcomes;
- Identifying data literacy and statistical literacy instructional resources that can be used or adapted; and
- Identifying data literacy, statistical literacy, and graph literacy measures that can be used or adapted.

Resource Guide Sections

This *Teaching and Assessing Data Literacy: Resource Guide for Supporting Pre-Service and In-Service Teachers* contains three sections.

- Section 1: Data Literacy Definitions, Learning Outcomes, and Frameworks
- Section 2: Instructional Resources for Teaching Data Literacy and Statistical Literacy to Pre-Service and Early Career In-Service Teachers
- Section 3: Data Literacy, Statistical Literacy, and Graph Literacy Measures

Section 1: Data Literacy Definitions, Learning Outcomes, & Frameworks

Definitions

As the use of data in schools grows, the need for data literate teachers has become more important than ever. However, confusion regarding the definition of data literacy exists among the teacher preparation field and the term data literacy is not widely used among PK-12 teachers and administrators. Mandinach and Gummer (2016) present the following definition of data literacy, which was used to identify useful frameworks, instructional resources, and measures for this guide.

> Data literacy for teaching is the ability to transform information into actionable instructional knowledge and practices by collecting, analyzing, and interpreting all types of data (assessment, school climate, behavioral, snapshot, longitudinal, moment-to-moment, etc.) to help determine instructional steps. It combines an understanding of data with standards, disciplinary knowledge and practices, curricular knowledge, pedagogical content knowledge, and an understanding of how children learn. (p. 367)

Being data literate includes a large subset of skills that allow for data to be understood and used in an appropriate and effective manner. For example, statistical literacy and graphical competency can be viewed as subcategories to data literacy as they emphasize specific sets of skills within a larger understanding of how to use data. Chick and Pierce (2012) write that statistical literacy is the "sufficient knowledge and understanding of numeracy, statistics, general literacy, and data presentation to make valuable use of quantitative data and summary reports" for one's professional practice (p. 3). Additionally, according to the authors, it includes the ability to question how the data were collected, to understand and interpret possible causes and consequences of the data, and to highlight the limitations of the data at hand. Chick and Pierce (2012) claim the basic math skills learned in elementary and secondary education and preliminary college math courses is not sufficient for teachers entering the field to be considered statistically literate.

Additionally, Gonzalez, Espinel, and Ainley (2011) highlight the low levels of graphical competency demonstrated by teachers and the lack of research surrounding the topic. Considering how important graphical competency is for being statistically literate and data literate, this is a concern that should be addressed through teacher preparation programs and teacher professional development opportunities.

This section of the Resource Guide outlines data literacy learning outcomes, associated concepts critical to address when teaching data literacy, foundational knowledge and skills

related to statistical literacy, and data literacy challenges for teachers. Frameworks related to data literacy learning outcomes are then presented. The section concludes with ideas for applying the information presented to the development of program requirements and instruction to enhance the data literacy knowledge and skills of pre-service and in-service teachers.

Learning Outcomes

Based on a review of the literature, learning outcomes for teaching data literacy and statistical literacy for pre-service and early career in-service teachers are outlined. As noted in the introduction to this Resource Guide, the Data Quality Campaign (2014) recommended states include data literacy skills in their teacher licensure policies. Arizona followed this recommendation and includes data literacy knowledge and skills as a required element in rule language for the state program review approval process of teacher preparation programs. The Arizona rule language defines data literacy for teacher preparation curricula as "evidence that candidates are provided instruction and practice in how to gather, evaluate, and synthesize multiple data sources and how to effectively use data in educational and classroom instructional decisions" (Arizona Secretary of State, 2020, p. 50). The Data Literacy Matrix, a required Arizona Department of Education program review form, asks Educator Preparation Providers to document evidence of teacher candidates' competencies in relation to the Data Literacy Policy Framework (Data Quality Campaign, 2014) components:

- Continuously: Using data as part of daily routines and on an ongoing basis, rather than as a one-time event
- Effectively: Using data to inform improved and tailored instruction and other practices for the purposes of improving student learning
- Ethically: Know and apply information with professionalism and integrity for intended uses only, and with consciousness of the need to protect student privacy
- Access: Know the multiple types of data available (including but not limited to assessment data), understand which data are appropriate to address the question at hand, and know how to access the possible sources of data
- Interpret: Analyze and synthesize data to make the information appropriate for addressing the given problem or question
- Act: Take relevant information and apply it to generate further questions and/or apply it to decision making appropriate to the given question
- Communicate: Share data points and the information synthesized from relevant data with stakeholders including parents, students, peers, principals, and other applicable, to generate further questions, inform decision making, or provide a better understanding of student learning. (p. 6)

To effectively teach these components, specific data and statistical literacy learning outcomes are needed. Several sources from the literature recommend specific learning outcomes that provide a starting point for developing and sequencing learning objectives for teacher preparation programs.

Means, Chen, DeBarger, and Padilla (2011) studied how teachers use data, which led to the following recommended data literacy skills. Teachers need to be able to:

- Find the relevant pieces of data in the data system or display available to them (data location)
- Understand what the data signify (data comprehension)
- Figure out what the data mean (data interpretation)
- Select an instructional approach that addresses the situation identified through the data (instructional decision making)
- Frame instructionally relevant questions that can be addressed by the data in the system (question posing). (p. viii)

Similarly, Wayman, and Jimerson (2014) conducted focus groups and surveyed teachers to better understand what teachers need to know regarding data use. They found the following skills were needed:

- Asking the right questions [to guide analysis and use]
- Integrating data use with curriculum, instruction, and assessment
- Analyzing and interpreting data
- Linking data to classroom practice
- Computer skills
- Collaborating around data. (p. 28)

The data literacy skills recommended by Means et al. (2011) and Wayman and Jimerson (2014) are similar, but it is interesting to note that Wayman and Jimerson lead with “asking the right questions” (p. viii) whereas Means et al. conclude with “question posing” (p. 28). This points to the cyclical nature of this work represented below through multiple frameworks.

Jimerson and Wayman (2015) articulate an additional learning outcome, the importance of teacher training related to “accessing and operating data systems” (p. 14). This is similar to the learning outcome proposed by Means et al. “Find the relevant pieces of data in the data system or display available to them (data location)” (p. viii), but Jimerson and Wayman articulate a focus on the need for training opportunities related to data systems.

Mandinach and Gummer (2013; 2016), leading authors in the area of data literacy for educators, also propose several data literacy knowledge and skills needed by educators. The authors recommend “knowing how to identify, collect, organize, analyze, summarize, and prioritize data. They also include how to develop hypotheses, identify problems, interpret the data, and determine, plan, implement, and monitor courses of action” (p. 30), which reiterate findings noted in the previous studies. Mandinach and Gummer’s (2016) publication is based on the results of convening a 55 member expert panel and provides a comprehensive listing of descriptions for data literacy knowledge and skills aligned to data literacy and statistical literacy ideas noted in this section, as well as components of a conceptual framework they developed titled *Data Literacy for Teachers*. Mandinach and Gummer’s (2016) publication serves as a valuable resource for teacher educators for developing measurable learning objectives for teaching key data literacy competencies.

In addition to the Data Literacy Policy Framework described previously, the Data Quality Campaign (2014) also suggests the following listing of 10 data literacy skills as critical for teachers.

Skill 1. Access and gather relevant data from available sources
Skill 2. Synthesize and analyze diverse data
Skill 3. Know about and use student-level and other types of data beyond assessment data
Skill 4. Understand how to use different types of data
Skill 5. Engage in a data-driven and cyclical inquiry process
Skill 6. Use data to tailor instruction to diverse groups of students
Skill 7. Use one's own data
Skill 8. Facilitate student understanding of data
Skill 9. Communicate about data with diverse internal and external stakeholders
Skill 10. Know about and be able to use data that are currently applicable for and relevant to practice. (pp. 1-7)

This listing includes a few skills that extend beyond those already discussed (i.e., Skills 3, 5, and 8).

Associated Concepts for Teaching Data Literacy

One associated concept for teaching data literacy is the importance of understanding the context of the data results (Chick & Pierce, 2012; Pierce & Chick, 2011; Pierce & Chick, 2014; Pierce, Chick, Walton, Les, & Dalton, 2014). Pierce and Chick (2011) highlight "a framework for considering professional statistical literacy" (p. 633), which conveys the concept of statistical literacy within a teacher's perspective. To fully grasp how to utilize statistical data results, an understanding of the context from which the data were derived is critical. This idea of understanding the context of data results relates to the competencies of data comprehension, analysis, and interpretation.

Another important concept reflected within the data literacy literature is collaboration (i.e., the ability to work on a data team). Teachers must possess the ability to work with others and utilize resources (both human and computer) for their work.

Foundational Statistical Literacy Knowledge and Skills

Several studies outline specific, foundational skills teachers need to be considered statistically literate such as being able "to recognise the role assessment can play in supporting and not just measuring learning" (Cowie & Cooper, 2017, p. 148). To be able to do this successfully, teachers need to possess a degree of numeracy competency to allow for the mathematical thinking necessary to analyze and use data results to inform instructional decisions. Numeracy is defined as "[...]skills that aren't always taught in the classroom – the ability to use numbers and solve problems in real life. It means having the confidence and skill to use numbers and mathematical approaches in all aspects of life" (National Numeracy, 2014-2020). The ability to use numbers and mathematical approaches to solve problems encountered

as a teacher data results relates to the competencies of data comprehension, analysis, and interpretation. Numeracy competency is directly tied to the data literacy challenges for teachers identified researchers.

Data Literacy Challenges for Teachers

Mandinach and Gummer (2013) note data literacy challenges for teachers. They state that "some educators seemed trepidatious about the decisions they made based on data, worried that they might not understand the data well enough" (p. 29). In addition, the literature reviewed also highlighted two other challenges for pre-service and early career teachers related to data analysis and the use of data for informing instructional decisions. The challenges identified include teachers:

1) being overwhelmed when they interpret the presentation of data as complex (Pierce & Chick, 2011), and
2) difficulty analyzing multiple data points or conducting deeper analysis of data sets (Cowie & Cooper, 2017).

Pierce and Chick's (2011) study noted teachers conveyed being overwhelmed by graphical and table representations of data. Their data analysis also included quotes from teachers describing "uncertainty or confusion over some or all aspects of the data" (p. 638). Cowie and Cooper (2017) also cited findings from a study documenting teachers struggling "with examining multiple data points simultaneously (i.e., school and district scores over time), distinguishing absolute values and proportions, and identifying patterns within data" (p. 149). These findings highlight the importance of teaching data and statistical literacy skills and providing pre-service and in-service teachers with opportunities to apply these skills using authentic student data and contextual situations.

Frameworks

The review of the literature yielded numerous frameworks for data literacy and data-based decision making. The data literacy frameworks provide an overarching visual of the process of using data to inform instructional decisions; these frameworks are presented first. The data-based decision making models integrate statistical and graph literacy knowledge and skills through identifying specific steps to follow. These frameworks can be used in conjunction with the listing of learning outcomes to aid learning approaches. The name or title of the framework is listed first, then the reference(s) for the frameworks, next a brief description of the framework, and finally a link to a website or copy of the publication to access an image of the framework.

Conceptual Framework for Data Literacy for Teachers (DLFT)	
Framework Reference(s)	Mandinach, E. B., & Gummer, E. S. (2016). What does it mean for teachers to be data literate: Laying out the skills, knowledge, and dispositions. *Teaching and Teacher Education, 60*,

	366-376. https://doi.org/10.1016/j.tate.2016.07.011
Brief Description	The Conceptual Framework for Data Literacy for Teachers (DLFT) is visualized as a large funnel where multiple contextual aspects of education are considered. These contextual aspects include "content knowledge; curriculum knowledge; knowledge of learners and their characteristics; knowledge of educational ends, purposes, and values; general pedagogical knowledge; pedagogical content knowledge; and knowledge of educational contexts" (Mandinach & Gummer, 2016, p. 369). The conceptual framework then depicts "Data Use for Teaching" (p. 369) as a process that requires information regarding the contextual aspects noted above and impacts these contextual aspects. "Data Use for Teaching" is defined by the following components (p. 369): ● Identify Problems/Frame Questions ● Use Data ● Transform Data Into Information ● Transform Information Into Decision ● Evaluate Outcomes
Online access to information regarding framework/model	https://www.researchgate.net/publication/306087171_What_does_it_mean_for_teachers_to_be_data_literate_Laying_out_the_skills_knowledge_and_dispositions

Data Wise Improvement Process	
Framework Reference(s)	Bocala, C., & Boudet, K. P. (2015). Teaching educators habits of mind for using data wisely. *Teachers College Record, 117*(4), 1-20. https://www.tcrecord.org/Content.asp?ContentID=17853 Boudett, K. P., City, E. A., & Murnane, R. J. (Eds.). (2013). *Data Wise: A step-by-step guide to using assessment results to improve teaching and learning, revised and expanded edition*. Cambridge, MA: Harvard Education Press. https://www.hepg.org/hep-home/books/data-wise,-revised-and-expanded-edition
Brief Description	The Data Wise Improvement Process is composed of three phases: Prepare, Inquire, and Act. The phases are further broken into eight steps (Bocala & Boudet, 2015, p. 6): 1. Organize for Collaborative Work 2. Build Assessment Literacy 3. Create Data Overview 4. Dig Into Student Data

	5. Examine Instruction 6. Develop Action Plan 7. Plan to Assess Progress 8. Act and Assess The process is intended for use by teachers to implement evidence-based analysis of relevant data results. The Harvard Graduate School of Education Data Wise Project provides professional development support for educators regarding the Data Wise Improvement Process.
Online access to information regarding framework/model	https://datawise.gse.harvard.edu/data-wise-improvement-process

Data-Based Decision Making Model	
Framework Reference(s)	Cramer, E. D., Little, M. E., & McHatton, P. A. (2014). Demystifying the data-based decision-making process. *Action in Teacher Education, 36*(5-6), 389-400. https://doi.org/10.1080/01626620.2014.977690
Brief Description	The Data-Based Decision Making Model focuses on a continuous cycle of "Goal Identification," "Data Collection," "Data Reflection," and "Areas of Improvement." Central components of this work include "Collaboration" with colleagues and "Dissemination" of results (Cramer et al., 2014, p. 391). The model is applicable in a variety of educational settings, including PK-12 classrooms, PK-12 schools, school districts as well as institutions of higher education.
Online access to information regarding framework/model	https://www.researchgate.net/publication/275034044_Demystifying_the_Data-Based_Decision_Making_Process

Conceptual Framework for Data-Driven Decision Making	
Framework Reference(s)	Mandinach, E. B. (2012). A perfect time for data use: Using data-driven decision making to inform practice. *Educational Psychologist, 47*(2), 71-85. https://doi.org/10.1080/00461520.2012.667064

Brief Description	The Conceptual Framework for Data-Driven Decision Making includes the following components: classroom implementation of data collection, transformation of data into information and knowledge, and then use of data to inform instructional decisions and positively impact student learning (Mandinach, 2012).
Online access to information regarding framework/model	https://www.researchgate.net/figure/Conceptual-framework-for-data-driven-decision-making-Reprinted-with-permission-from-A_fig1_233146642

Data-Based Decision Making Theory of Action	
Framework Reference(s)	Kippers, W. B., Poortman, C. L., Schildkamp, K., & Visscher, A. J. (2018). Data literacy: What do educators learn and struggle with during a data use intervention? *Studies in Educational Evaluation, 56*, 21-31. https://doi.org/10.1016/j.stueduc.2017.11.001
Brief Description	The Data-Based Decision Making Theory of Action proposes a cyclical approach to implementing data and statistical literacy skills. It starts with articulating a purpose including defining the problem and/or formulating a question. The next steps are collecting, analyzing, and interpreting the data. Based on the results of the analysis and confidence in the data collected as well as the interpretation of the data, it may be appropriate to redefine the purpose and data collection instrument or procedures, or take instructional action (Kippers et al., 2018).
Online access to information regarding framework/model	https://research.utwente.nl/en/publications/data-literacy-what-do-educators-learn-and-struggle-with-during-a-

Literacy 3D Steps (3D = Data-Driven Decisions)	
Framework Reference(s)	Abbott, M., Beecher, C., Petersen, S., Greenwood, C. R., & Atwater, J. (2017). A team approach to data-driven decision-making literacy instruction in preschool classrooms: Child assessment and intervention through classroom team self-reflection. *Young Exceptional Children, 20*(3), 117-132. https://doi.org/10.1177/1096250615602297

Brief Description	The Literacy 3D Steps framework provides data-driven decision making strategies that are specific to data literacy and also demonstrates a continuous cycle. The steps in the cycle are similar to others frameworks presented and include (Abbott et al., 2017): 1. Collect child data. 2. Observe instruction. 3. Review of child data. 4. Identify a target skill. 5. Reflect on current practice. 6. Identify Top 10 strateg[ies]. 7. Write a goal, plan, review & practice. 8. Collect fidelity of implementation. 9. Provide fidelity feedback. (p. 120)
Online access to information regarding framework/model	https://eric.ed.gov/?id=EJ1151410

Framework for Data Literacy and Use for Teaching	
Framework Reference(s)	Wasson, B., & Hansen, C. J. S. (2016). Data literacy and use for teaching. In P. Reimann, S. Bull, M. D. Kickmeier-Rust, R. Vatrapu, & B. Wasson (Eds.), *Measuring and Visualizing Learning in the Information-Rich Classroom* (pp. 56-73). Routledge. https://doi.org/10.4324/9781315777979
Brief Description	The Framework for Data Literacy and Use for Teaching consists of five points that teachers should understand (Wasson & Hansen, 2016): 1. How the configuration of technology tools or applications impacts the data generated (conceptually and technically); 2. What and how data is generated by a tool or application; 3. How the data is analysed (if it is done automatically); 4. How the data/data interpretation can be used in a pedagogical manner (for both teaching and formative assessment); and 5. How the data and data interpretation can be shared. (p. 66) These five points lead to specific actions a teacher can engage in to use data to inform instructional decisions.

Online access to information regarding framework/model	https://www.researchgate.net/publication/290445323_Data_Literacy_and_Use_for_Teaching

Steps in the Data-Based Decision Making Process	
Framework Reference(s)	Filderman, M. J., & Toste, J. R. (2018). Decisions, decisions, decisions: Using data to make instructional decisions for struggling readers. *TEACHING Exceptional Children, 50*(3), 130-140. https://doi.org/10.1177/0040059917740701
Brief Description	Steps in the Data-Based Decision Making Process include (Filderman & Toste, 2018): 1. Implement intensified intervention 2. Monitor progress (Graph and interpret data; evaluate progress in relation to goals and expectations) a. Intervention is working - Continue to implement intensified intervention and monitor progress b. Intervention is not work [go to Step 3] 3. Diagnostic assessment (What isn't working? What have we tried? What do the data tell us we should do differently?) 4. Adapt intervention (Target specific skills, adjust delivery of intervention, or adjust pacing of intervention.) a. Repeat process by going to Step 2, Monitor progress (p.133) This publication discusses the above model specifically in relation to working with struggling readers and implementing reading interventions.
Online access to information regarding framework/model	https://eric.ed.gov/?id=EJ1167006

Summary

This section provided foundational information regarding data literacy definitions, learning outcomes, and frameworks. The compilation of this information is intended to facilitate the work of teacher preparation faculty in the development of meaningful data literacy instruction. As noted through the information presented, there are multiple sets of learning outcomes and frameworks presented from the literature that were developed based on research findings. One or more sets of learning outcomes and frameworks can be used as the basis for

developing data literacy instruction. Additionally, studies identified key associated concepts and challenges for teachers related to developing data literacy knowledge and skills. Necessary foundational knowledge upon which deeper data and statistical literacy skills can be developed were also presented. This implies the importance of reviewing teacher preparation admission and program requirements to ensure required and recommended courses are aligned and develop the fundamental knowledge needed to further develop data literacy for teacher candidates. The table below includes several ideas for applying the information presented in this section to developing or further enhancing data literacy instruction for teacher preparation programs.

Application Ideas

- Given Chick and Pierce's (2012) claim that the basic math skills learned are not sufficient for teachers entering the field to be considered statistically literate as well as Cowie and Cooper's (2017) comments regarding the importance of numeracy competency for teachers:
    - consider working with the Mathematics Department faculty to re-review math course admission requirement(s) to determine if they are providing the best foundational knowledge and skills both for the program expectations and for developing data and statistical literacy skills as well as graphical competency
    - develop a list of recommended math courses that also count for general education or liberal studies requirements while enhancing teacher candidate knowledge and skills related to statistical literacy and graphical competency
- Choose data literacy knowledge or skills learning outcomes and one or more of the frameworks presented, and use the detailed definitions in the Mandinach and Gummer (2016) publication to develop measurable learning objectives for data literacy instruction through a program of study
- Check out the Data Quality Campaign (https://dataqualitycampaign.org/) videos and publications to identify useful instructional resources for teacher candidates (e.g., You Need Data to Personalize Learning [video] and Data Literacy 101 [summary and info graphic])
- Based on teacher concerns regarding "not understanding data well enough" (Mandinach & Gummer, 2013, p. 29) to make informed data-based decisions and the importance of understanding the contexts from which the data are derived, develop data literacy instruction that incorporates authentic academic and non-academic student data, associated instruments, and contextual scenarios (see Instructional Resources and Measures sections of this guide)

Section 2: Instructional Resources for Teaching Data Literacy & Statistical Literacy to Pre-Service & Early Career In-Service Teachers

This section provides instructional resources to assist in the development of materials, syllabi, and educational opportunities/training in data literacy and statistical literacy practices. Publications in this section provide explicit instructional resources related to data literacy and/or statistical literacy or, in some cases, the entire publication constitutes the resource. A citation for each publication is included to assist in locating it.

The description for each resource contains suggestions regarding how to use the resource and the appropriate level(s) for the resource are noted. The levels include:

- Early pre-service: instructional resource could be implemented near beginning of program as minimal to no background knowledge needed
- Advanced pre-service: instructional resource could be implemented near end of program as background knowledge or prerequisites needed
- Early career in-service: instructional resource could be implemented during first 3-5 years of teaching
- Both advanced pre-service and early career in-service teachers

Additionally, where applicable, implementation time is delineated and assessments used within the instructional resource are noted.

Finally, Appendix A includes instructional resources that were not identified in the systematic literature review process (e.g., because the resource is a website not described in a publication), but offer valuable materials that could be utilized to teach data literacy and/or statistical literacy. Brief descriptions in relation to teaching data literacy and/or statistical literacy are also included for these additional instructional resources listed in Appendix A.

Instructional Resources for Early Pre-Service Teachers

Probability and Statistics for Teachers	
Instructional Resource Reference(s)	Metz, M. L. (2010). Using GAISE and NCTM Standards as frameworks for teaching probability and statistics for pre-service elementary and middle school mathematics teachers. *Journal of Statistics Education, 18*(3), 1-27. www.amstat.org/publications/jse/v18n3/metz.pdf

What is Being Taught by the Instructional Resource	Statistical literacy knowledge and skills to provide pre-service teachers with conceptual statistical knowledge, particularly related to probability and data analysis as well as the "connections between the statistical concepts they are learning and the statistical concepts they will someday teach to elementary and middle school students" (Metz, 2010, p. 1)
Appropriate Level(s)	Early pre-service
How to Access/Use the Instructional Resource	This instructional resource could be utilized based on the publication itself, which includes the course outline as well as excerpts from a lesson sequence related to the *Typical Person Activity* and appendices related to the Guidelines for Assessment and Instruction in Statistics Education (GAISE) and National Council of Teachers of Mathematics (NCTM) standards.
Time Required for Resource Implementation	Entire semester of a 3-credit undergraduate course
Assessment(s)	Two major assignments were given in relation to this instruction: ● "The first assignment required pre-service teachers to use the problem solving process in designing and carrying out a statistical study" (p. 17); and ● "The second assignment required the pre-service teachers to teach a mini-lesson to their peers that developed a concept related to descriptive statistics at the elementary or middle school level [...and followed] the statistical problem solving process" (p. 18).
Summary	Metz (2010) describes a *Probability and Statistics for Elementary and Middle School Teachers* undergraduate course that was revised and implemented using the GAISE framework and NCTM Standards with an emphasis on data analysis and probability. The course used real-world situations and data to facilitate statistical learning as well as the teaching of statistical concepts to elementary and middle school students. The driving force behind the course design was for " teachers at all levels to be statistically literate themselves and possess the pedagogical tools necessary to provide quality learning experiences that develop and deepen their students' statistical understanding" (p. 19).

Course-Embedded Data Literacy Intervention	
Instructional Resource Reference(s)	Reeves, T. D., & Honig, S. L. (2015). A classroom data literacy intervention for pre-service teachers. *Teaching and Teacher Education, 50*, 90-101. http://dx.doi.org/10.1016/j.tate.2015.05.007
What is Being Taught by the Instructional Resource	Data literacy knowledge and skills for scoring, analysis, interpretation, and data-based decision making of teacher-made traditional and performance assessments as well as attitudes and beliefs regarding data use
Appropriate Level(s)	Early pre-service
How to Access/Use the Instructional Resource	Publication includes detailed descriptions of the two day intervention content and activities as well as the materials provided to students. The publication author would need to be contacted to request a copy of the training protocol, materials (Microsoft Excel and Word files) provided to students, and the items on the objective test of participants' data literacy knowledge. The nine assessment belief scales from the *Conceptions of Assessment III--Abridged's (COA-III*; Brown, 2006) and the data attitude and belief scales from the *Survey of Educator Data Use's* data attitude and belief scales (SEDU; Wayman, Cho, & Shaw, 2009) are available in their original publications.
Time Required for Resource Implementation	2 days/class sessions (6 hours)
Assessment(s)	• The *COA-III* nine assessment belief scales (Brown, 2006) and the SEDU's data attitude and belief scales (Wayman, Cho, & Shaw, 2009) were administered pre- and post-intervention. The SEDU was used to measure beliefs/attitudes related to Data Effectiveness for Pedagogy, Data Attitudes, and Data Self-Efficacy. The COA-III measured beliefs/attitudes regarding: Assessment Describes Abilities, Assessment Improves Learning, Assessment Improves Teaching, Assessment is Bad, Assessment is Ignored, Assessment is Inaccurate, Assessment is Valid, Assessment Makes Schools Accountable, and Assessment Makes Students Accountable. • A 13-item, objective pre- and post-test of data literacy knowledge (adapted from Means et al. 2009). These items

	required pre-service teachers “to interpret z-scores and dichotomous item difficulties, read and interpret tables and graphs, compare scores across groups and over time, compare group scores and individual scores represented in tables, and identify evidence that would best support particular instructional decisions” (Reeves & Honig, 2015, pp. 95-96).
Summary	This course-embedded data literacy intervention provided pre-service teachers with practical experience in data scoring, analysis, interpretation, and data-based decision making. Prior to the intervention, pre-service teachers designed and constructed two summative assessments, a traditional assessment and a performance assessment. These assessment instruments were administered to actual K-12 students and data were collected. During the intervention, pre-service teachers were provided with worksheets and other resources (such as Microsoft Excel spreadsheets) to assist them in analyzing, interpreting, and making decisions based on the data. After the intervention, the pre-service teachers reported a heightened understanding of the importance of data use, as well as a slightly higher understanding of how to collect, analyze, and use data effectively.

Case-Based Teaching Method	
Instructional Resource Reference(s)	Riddle, D. R., Beck, J. S., Morgan, J. J., Brown, N., & Whitesides, H. (2017). Making a case for case-based teaching in data literacy. *Kappa Delta Pi Record, 53*(3), 131-133. https://doi.org/10.1080/00228958.2017.1334479
What is Being Taught by the Instructional Resource	Data literacy skills guided by the data inquiry cycle created by National Forum on Education Statistics (2012), which includes the “five principles in cyclical process: (a) seek information; (b) access and gather data; (c) analyze and interpret data; (d) act; and (e) evaluate[; t]hese principles can be taught in an isolated fashion” (Riddle, Beck, Morgan, Brown, & Whitesides, 2017, p. 132)
Appropriate Level(s)	Early pre-service
How to Access/Use the Instructional Resource	Publication provides information for utilizing the case-based teaching method including the general definition of the method, approaches (with a recommendation for use of incomplete cases when using the method to teach data literacy skills), and the three

	main steps for developing cases for teaching data literacy (i.e., chosen data literacy principles, determining baseline data literacy knowledge and skills, and selecting or designing case materials that align with chosen principles). Table 1 of the publication provides considerations and sample materials for case-based teaching of the five data-based decision making principles in the National Forum on Education Statistics' (2012) data inquiry cycle.
Time Required for Resource Implementation	Ongoing and continual, starting early in teaching preparation programs
Assessment(s)	• Determining baseline knowledge of data literacy skills is suggested (e.g., using pre-tests, discussions, review of previous and subsequent course materials, etc.). • Use of assessments (such as culminating or capstone projects), as deemed appropriate by a teacher educator program, may be useful in providing "teacher educators with data on teacher candidates' proficiency of these [data literacy] skills" (p. 132).
Summary	"Case-based teaching allows for work with authentic data and provides teacher educators opportunities to teach data-literacy principles using discrete methods that accommodate corrective feedback" (p. 132).

Instructional Resources for Advanced Pre-Service Teachers

Modeling, Magnitudes, Data and Change (MMDC) Course	
Instructional Resource Reference(s)	Biehler, R., Frischemeier, D., & Podworny, S. (2017). Elementary preservice teachers' reasoning about modeling a "family factory" with TinkerPlots: A pilot study. *Statistics Education Research Journal, 16*(2), 244-286. http://iase-web.org/documents/SERJ/SERJ16%282%29_Biehler.pdf
What is Being Taught by the Instructional Resource	Statistical literacy knowledge and skills related to data analysis as well as probability with simulated chance experiments
Appropriate Level(s)	Advanced pre-service
How to Access/Use the Instructional Resource	This instructional resource could be utilized based on the publication itself, which includes the course content (see Table 1 of the publication), task instructions given to pre-service teachers

	(see Figure 1 of the publication), and details about conducting the task in TinkerPlots including appendices for statistical phases, TinkerPlot phases, and interventions (see Appendices A, B, and C of the publication, respectively).
Time Required for Resource Implementation	12 lectures
Assessment(s)	Task where pre-service teachers "were asked to set up and evaluate their own models with TinkerPlots by using a real and open dataset they were given" (Biehler, Frischemeier, & Podworny, 2017, p. 244).
Summary	Biehler et al. (2017) underscore the importance that "connecting data and chance is fundamental in statistics curricula" (p. 244). The use of statistical software, TinkerPlots, assisted students in setting up and evaluating their own models using real data and the reasoning applied during this process.

Science Inquiry Project	
Instructional Resource Reference(s)	Cook, K. L., & Bush, S. B. (2015). Structuring a science-mathematics partnership to support preservice teachers' data analysis and interpretation skills. *Journal of College Science Teaching, 44*(5), 31-37. https://www.jstor.org/stable/43631845
What is Being Taught by the Instructional Resource	Data literacy and statistical literacy knowledge and skills for the analysis and interpretation of data in relation to science inquiry
Appropriate Level(s)	Advanced pre-service
How to Access/Use the Instructional Resource	This instructional resource could be utilized based on the publication itself, which includes the project schedule (aligned to national science and mathematics standards), details about the tasks listed in the schedule with accompanying tables and figures, and notes to educators (e.g., notes about the tasks and their implementation; tips about areas where pre-service teachers may have difficulties and need extra support).
Time Required for Resource Implementation	8.5 hours across six class sessions

Assessment(s)	• Gallery walk of final version of each groups' graphical representation where pre-service teachers provided feedback to their peers on their group's graph by responding to the following prompt: "Interpret this graph. What suggestions would you make to improve this data display?" (Cook & Bush, 2015, p. 37). • During the final class session for this unit/project, pre-service teachers "created a claims, evidence, reasoning chart (CER) for their inquiry experience" (p. 35).
Summary	Cook and Bush (2015) created an integrated unit across their science and mathematics methods undergraduate courses to "support [pre-service teachers'] understanding of how to analyze and interpret data and their ability to teach it in their future classrooms" (p. 31). The integrated unit involves hands-on activities or tasks, class discussions, and group work for a scientific inquiry project that incorporates scaffolds to provide pre-service teachers with opportunities "to apply their developing knowledge of data analysis and interpretation to a scientific inquiry" project (p. 31).

Data Use Pedagogical Strategy	
Instructional Resource Reference(s)	Reeves, T. D. (2017). Equipping preservice elementary teachers for data use in the classroom. *Action in Teacher Education, 39*(4), 361-380. https://doi.org/10.1080/01626620.2017.1336131
What is Being Taught by the Instructional Resource	Data literacy knowledge and skills related to assessment scoring, data analysis and interpretation, and data-based decision-making
Appropriate Level(s)	Advanced pre-service; given the previous knowledge and skills needed for this instruction, it is recommended that this instructional resource be used at the end of an assessment course and/or near the completion of a program of study.
How to Access/Use the Instructional Resource	Publication includes the author's step-by-step protocol (see Appendix in publication) and examples from the author's qualitative worksheet, raw data worksheets, item score frequency distribution worksheets, and data-based worksheet; all materials including the Excel-based data analysis tools and scripts are available from the publication author upon request.

Time Required for Resource Implementation	2 days/class sessions (6 hours)
Assessment(s)	• Qualitative Analysis Worksheet to identify patterns of incorrect assessment responses (see Figure 1 of publication for a completed worksheet example) • Raw Data Worksheets, one for a traditional assessment and one for a performance assessment, to enter numeric scores and perform calculations; these raw data worksheets were Excel-based (see Figure 2 of publication for an example of a completed raw data worksheet) • Item Score Frequency Distribution Worksheets were also Excel-based for the traditional and performance assessments to “tabularly and graphically represent overall class performance on select items or rubric dimensions” (Reeves, 2017, p. 386; see Figure 3 of publication for a completed worksheet example) • Data-Based Decision Making Worksheet “involves formally making claims/decisions [for each assessment] based on the data [...] about: overall class performance, strengths and weaknesses, and errors or misconceptions” (p. 368; see Figure 4 of publication for a completed example)
Summary	This pedagogical strategy is intended to provide pre-service teachers with a crash-course in data literacy, including "assessment scoring, data analysis, interpretation, and data-based decision making" (p. 364). Data are collected from actual K-12 students based on teacher-designed assessments, as it is important for pre-service teachers to contextualize the data when analyzing it. Overall, pre-service teachers were provided with training worksheets and other resources (i.e., Microsoft Excel spreadsheets) to assist them in analyzing, interpreting, and making decisions based on the data. More specifically, day one of the training primarily focused on scoring of the assessments as well as qualitative analysis of student work and entering scores from assessment into Excel-based raw data worksheets. Day two of the experience primarily focused on the analysis and interpretation of the data from the assessments and making decisions based on the data, including (but not limited to) completion of the Item Score Frequency Distribution Worksheets and Data-based Decision Making Worksheet.

Data-Driven Decision Making Using CaseMate Tool	
Instructional Resource Reference(s)	Swan, G., & Mazur, J. (2011). Examining data driven decision making via formative assessment: A confluence of technology, data interpretation heuristics and curricular policy. *Contemporary Issues in Technology and Teacher Education, 11*(2), 205-222. https://www.learntechlib.org/primary/p/36021/
What is Being Taught by the Instructional Resource	Use of a tool (i.e., the CaseMate tool) for data-driven decision making based on formative assessment data
Appropriate Level(s)	Advanced pre-service
How to Access/Use the Instructional Resource	This instructional resource could be utilized based on the publication itself, which includes details of the stages, the questions for the analytic task, and screenshots from the CaseMate tool.
Time Required for Resource Implementation	Four stages: 1) pre-survey (completed in the CaseMate environment) and reading related to formative assessment, 2) demonstration of the tool using the pre-survey data, 3) a short analytic task involving use of the tool (approximately 10 minutes), and 4) post-survey.
Assessment(s)	Analytic task involving working with two sets of data (one color coded and one not color coded), and answering a couple of questions based on the data sets.
Summary	Swan and Mazur (2011) describe an exploratory case study of advanced pre-service teachers' use of an open source, online tool (CaseMate) that can collect and display student-level data. The CaseMate tool can be used by teachers to support real-time data-driven decision making with formative assessments as the CaseMate "environment allows instructors to arrange various media elements with embedded[, web-enhanced] assessments that display and deliver students' assessments to the teacher" (p. 207).

Instructional Resources for Advanced Pre-Service and Early Career In-Service Teachers

Habits of Mind	
Instructional Resource	Bocala, C., & Boudett, K. P. (2015). Teaching educators habits of

Reference(s)	mind for using data wisely. *Teachers College Record, 117*, 1-20. https://www.tcrecord.org/Content.asp?ContentId=17853
What is Being Taught by the Instructional Resource	Habits of mind, or ways of thinking, that underlie the use of data wisely
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	The publication describes the ACE habits of mind as well as suggestions for incorporating these habits of mind both in pre-service teacher preparation courses and in-service professional development. Table 2 depicts "strategies for supporting educators to cultivate habits of mind" (ACE; p. 8). More information and resources can be found at: https://datawise.gse.harvard.edu/.
Time Required for Resource Implementation	"The key is to explicitly teach the habits and then create learning experiences that incorporate the habits holistically, such that participants have practice activating the habits over time" (Bocala & Boudett, 2015, p. 8). Strategies for each ACE habit of mind are described in the publication, and "[t]hese strategies can be incorporated into any course about improvement, not just those that use the Data Wise Improvement Process specifically" (p. 8).
Assessment(s)	Assessments center around the three ACE habits of mind ("shared commitment to action, assessment, and adjustment;" "intentional collaboration;" and "relentless focus on evidence") and include various assessment activities such as: "requiring thorough documentation of accomplishments and reflection," "requiring students to participate in the course as a team," and "using case studies to expose participants to a broad range of data" (p. 8; see Table 2 of the publication).
Summary	Habits of mind, or ways of thinking, underlying data literacy and the use of data wisely are described by Bocala and Boudett (2015) along with strategies for teaching these ACE habits of mind. More specifically, they begin by discussing "[...]the need to build data literacy as part of pre-service and ongoing professional learning for educators. [...]Next, they describe] the three habits of mind around data use that educators need the most support in developing. [...Finally, they discuss strategies] to cultivate these habits" (p. 2) using the Data Wise courses or into any other appropriate course in a program of study.

Statistical Literacy Lesson Planning Task	
Instructional Resource Reference(s)	Chick, H. L., & Pierce, R. (2012). Teaching for statistical literacy: Utilising affordances in real-world data. *International Journal of Science and Mathematics Education, 10*, 339-362. https://doi.org/10.1007/s10763-011-9303-2
What is Being Taught by the Instructional Resource	Statistical literacy knowledge and skills as well as the teaching of statistical literacy related to identifying affordances, planning an appropriate lesson to teach a statistical concept, and using data to inform one's instruction and lesson planning
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	Publication includes a proposed hierarchy for statistical literacy lessons (see Table 1 in the publication), details on the lesson planning task as well as the preliminary workshop including the questions posed to pre-service teachers.
Time Required for Resource Implementation	Two class periods (one for the preliminary workshop and one for the lesson planning task)
Assessment(s)	• Preliminary workshop involving a hands-on activity with real-world data and questions for the pre-service teachers to answer. • Lesson planning task requiring pre-service teachers "to examine a website containing real-world graphical and tabular information and prepare a lesson to teach some statistical principles of their choice" (Chick & Pierce, 2012, p. 346).
Summary	Teaching statistical literacy requires three facets: "First is the requirement that teachers have sufficient statistical literacy to be able to interpret and question the data. Second, teachers need the capacity to identify the statistical principles that can actually be taught through the data. Finally, teachers must be able to design lessons, with sound pedagogy, that bring to the fore the statistical principles to be learned by the students" (p. 341).

Data Chat	
Instructional Resource Reference(s)	Dunlap, K., & Piro, J. S. (2016). Diving into data: Developing the capacity for data literacy in teacher education. *Cogent*

	Education, 3(1), 1-13. https://doi.org/10.1080/2331186X.2015.1132526 Piro, J. S., Dunlap, K., & Shutt, T. (2014). A collaborative data chat: Teaching summative assessment data use in pre-service teacher education. *Cogent Education, 1*(1), 1-24. https://doi.org/10.1080/2331186X.2014.968409 Piro, J. S., & Hutchinson, C. J. (2014). Using a Data Chat to teach instructional interventions: Student perceptions of data literacy in an assessment course. *The New Educator, 10*(2), 95-111. https://doi.org/10.1080/1547688X.2014.898479
What is Being Taught by the Instructional Resource	Understanding, analysis, and use of data in collaborative data teams
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	This instructional resource could be utilized based on the publications, which include the eight steps for the Data Chat instructional invention (Piro, Dunlap, & Shutt, 2014, pp. 5-6), intervention content and steps, open-ended questions (Piro et al., p. 7, Table 2), pre- and post-test of content related to data literacy behaviors (Piro et al., p. 8, Table 3) with follow-up open-ended questions (Piro et al., p. 9, Table 4), and suggestions for developing and implementing a collaborative Data Chat.
Time Required for Resource Implementation	Four, 3-hour sessions
Measure(s) and Assessment(s)	• Measure: Pre/post-test of content linked to data literacy behaviors to measure data literacy knowledge and skills related to locating data in tables/graphs, comparing and manipulating data in tables/graphs, understanding and interpreting score distributions, making differentiated instruction decisions based on data, and interpreting data from tables/graphs. • Assessment: Final presentation following the Data Chat intervention, which consisted of information about: “data literacy group members; the type of data-set; the specific test; when the test was given; strengths and weaknesses of student performance; numeric, graphical, and narrative descriptions of the weakness areas; formative and summative assessments to be given prior to the next testing period, and instructional strategies for interventions” (Piro et al., 2014, p. 6).

	○ The publication recommended including some type of “final product for the Data Chat process. A final presentation or report such as a team of teachers might present to their data coach or administrator is an effective way to prepare pre-service teachers for their future practice in the classroom” (p. 20).
Summary	Instructional intervention to engage pre-service teachers in "data comprehension, analysis, and use in collaborative teams to prepare them for the practical realities of educational accountability and the iterative process of assessment and instruction by explicitly addressing data literacy" (p. 3) via a collaborative Data Chat team that simulates grade-level teams in schools. The Data Chat intervention focused on classroom level data sets for state-wide achievement tests at the 3-8 grade levels and end of the course assessments in grades 9-12 in varying content areas. The Data Chat intervention took place across four sessions where pre-service teachers gained understanding of foundational statistical terms and procedures, learned to read and comprehend data from data-sets and data reports, and worked in their groups to finalize and present analyses and instructional interventions for their teams’ data set.

National Assessment of Educational Progress (NAEP) Data Explorer	
Instructional Resource Reference(s)	Fitchett, P. G., & Heafner, T. L. (2013). Making critical connections between social studies teaching and student achievement using NAEP Data Explorer. *The Teacher Educator, 48*(4), 296-310. https://doi.org/10.1080/08878730.2013.827921
What is Being Taught by the Instructional Resource	Data literacy knowledge and skills for critically analyzing data
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	The NAEP Data Explorer is a free online application that can be accessed via: https://nces.ed.gov/nationsreportcard/data/. The Fitchett and Heafner (2013) publication includes a detailed explanation of an in-class data activity using the NAEP Data Explorer tool, exploratory questions for the small group portion of the activity to guide data analyses (see p. 299 of the publication), and follow-up survey questions including learning questions

	related to the data activity (see Appendix A of the publication).
Time Required for Resource Implementation	One class period of an advanced social studies methods course
Assessment(s)	● During the small group portion of the data activity, these guiding questions are addressed (Fitchett & Heafne, 2013): (a) What do these data tell us about the social studies teaching and instruction?, (b) What do they tell us about the students and their learning outcomes?, and (c) What do they tell us about the test? From small group discussions, we transition to a whole group debriefing in order to examine common trends among the data and what they can tell us about social studies teaching. (p. 299) ● Follow-up survey after completion of the data activity to determine how this practice of using NAEP data analysis informed their beliefs regarding social studies teaching and learning. Findings from this study were used to improve the quality of the activity and determine how teacher education students' examination of NAEP data influences their perception of social studies teaching and learning. (pp. 299-300)
Summary	Each year after NAEP data findings (across the various disciplines of U.S. history, civics, economics, geography, mathematics, reading science, writing, and the arts) are published in a "Nation's Report Card" technical report, "the National Center for Educational Statistics releases the data for analysis through the [NAEP] Data Explorer Tool[... allowing] exploratory analysis of NAEP scores associated with students demographics, school level variables, and students' reported exposure to various instructional practices" (p. 298). The in-class, data activity using the NAEP Data Explorer offers opportunities for data-driven discussions that involve critically analyzing the NAEP data in relation to student, school, and community factors as well as instructional content and practice. Further, the NAEP Data Explorer tool in the activity is used to "highlight [and discuss] complex educational issues associated with instructional decision making" (p. 297) while encouraging self-reflection and evaluation of "the instructional purposes and practices of their subject area" (p. 307).

TISL (Teacher Inquiry Into Student Learning) Heart Model and Method	
Instructional Resource Reference(s)	Hansen, C. J., & Wasson, B. (2016). Teacher inquiry into student learning: The TISL Heart Model and Method for use in teachers' professional development. *Nordic Journal of Digital Literacy, 11*(1), 24-49. https://doi.org/10.18261/issn.1891-943x-2016-01-02
What is Being Taught by the Instructional Resource	Model for teacher inquiry using student data to examine student learning as well as a method of the use of teacher inquiry by teachers involving the steps of kick-off, assumptions, research question, method, changing teaching and assessment, learning outcome, and feedback and sharing (see Table 3 of publication)
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	This instructional resource could be utilized based on the publication itself, which includes the revised TISL Heart model (see Figure 6 of the publication) and method (see Table 3 of the publication) with "trigger questions [for each step] to lead the teachers through the method" (Hansen & Wasson, 2016, p. 39).
Time Required for Resource Implementation	Single workshop session (approximately 60-90 minutes)
Assessment(s)	Engagement in the TISL Heart Method by progressing through the steps of the method, one step at a time, either individually or in small groups.
Summary	The TISL Heart Model and Method which is "a theory-practice model of teacher inquiry into student learning and a method for supporting its use by teachers" (p. 26). Hansen and Wasson (2016) describe TISL Heart as well as the workshop session implemented to introduce it. Specifically, the workshop started with an introduction to TISL Heart, and then gave teachers an opportunity to carry out each step of the TISL Heart Method, one at a time, either individually or in small groups by "discussing and answering the questions posted at each step" (p. 41; see Table 2 of the publication for the questions/tasks for each step of the TISL Heart Method).

Data Analysis and Probability Module	
Instructional Resource Reference(s)	Lee, H. S., & Lee, J. T. (2011). Enhancing prospective teachers' coordination of center and spread: A window into teacher education material development. *The Mathematics Educator, 21*(1), 33-47. https://eric.ed.gov/?id=EJ961509
What is Being Taught by the Instructional Resource	Data analysis and probability related to statistical literacy and statistical thinking, specifically involving intervals of data and measures of center
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	Publication includes examples of guiding questions, short transcripts from the module, and explanations of activities. More materials for the module can be found at http://ptmt.fi.ncsu.edu.
Time Required for Resource Implementation	5-week module
Assessment(s)	Pre- and post-tests before and after instructional implementation
Summary	Lee and Lee (2010) describe a 5-week course in statistical literacy and analysis created to help prepare middle and secondary mathematics teachers to teach data analysis and probability concepts with technology tools. The Data Analysis and Probability module contains three chapters to engage teachers as learners of statistics with larger multivariate data sets (e.g., national school data) to allow for the examination of data contextually as well as with statistics technology (TinkerPlots and Fathom). The Data Analysis and Probability module is not designed for teachers to use directly with their students, instead after completing the module, teachers will have the knowledge needed to create their own technology-based activities.

Data Scenarios	
Instructional Resource Reference(s)	Means, B., Chen, E., DeBarger, A., & Padilla, C. (2011). *Teachers' ability to use data to inform instruction: Challenges and supports*. U.S. Department of Education. https://www2.ed.gov/about/offices/list/opepd/ppss/reports.html
What is Being Taught by the Instructional Resource	Data literacy knowledge and skills related to the data literacy components of locating, comprehending, interpreting, and using

	data as well as posing questions based on data; each scenario addresses knowledge and skills for one or more of these data literacy components
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	"Part II of this report provides material that can be used in training teachers on the use of data to guide instruction" (Means, Chen, DeBarger, & Padilla, 2011, p. 5). There are seven data scenarios and each scenario includes the scenario description and data, questions related to the scenario data and relevant data literacy knowledge and skills, and commentary tables on what to look for in responses to each scenario in relation to each skill/concept. Finally, the Exhibit 17 table (see p. 69 of the publication) provides an overview of each scenario along with the skills and concepts addressed in relation to the data literacy components of: data location, data comprehension, data interpretation, data use, and question posing.
Time Required for Resource Implementation	Estimated at 30 minutes for each scenario
Assessment(s)	Each scenario includes questions for the data presented in the scenario in relation to the relevant data literacy knowledge and skills being addressed.
Summary	The data scenarios can be used for activities "to acquaint teachers with different kinds of data representations and different data interpretation issues" (p. 67) in teacher preparation programs and teacher professional development offerings. It is recommended that the data scenarios be used as a resource for discussion, particularly where teachers are organized into small groups for discussions and facilitation of the discussion occurs by training or a data coach. "By responding to questions in the data scenarios, teachers and administrators have the opportunity to deepen their understanding of skills and concepts essential to assessment and data analysis" (p. xi).

Statistical Literacy Workshop	
Instructional Resource Reference(s)	Pierce, R., Chick, H., & Wander, R. (2014). Improving teachers' professional statistical literacy. In H. MacGillivray, B. Phillips, & M. A. Martin (Eds.), *Topics from Australian Conferences on Teaching Statistics: OZCOTS 2008-2012* (pp. 295-309). New

	York: Springer. doi: 10.1007/978-1-4939-0603-1_16
What is Being Taught by the Instructional Resource	Statistical literacy knowledge and skills related to understanding, reading, and interpreting boxplots, engaging with data to learn about students, and using data to inform instructional planning
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	This instructional resource could be utilized based on the publication itself, which includes a framework for professional statistical literacy, workshop learning objectives, and detailed explanations of workshop tasks and activities.
Time Required for Resource Implementation	Half-day workshop
Assessment(s)	• Pre-workshop survey regarding attitudes, perceptions, and statistical literacy • Online post-workshop survey regarding attitudes, perceptions, and statistical literacy (administered four weeks after workshop)
Summary	Pierce, Chick, and Wander (2014) detail a workshop used to improve pre-service teachers' statistical literacy knowledge and skills. The workshop goals were to improve “barriers and misconceptions associated with analysing and interpreting system reports of student assessment” (p. 296). The workshop addressed these topics through hands-on activities intended to engage and evaluate teachers’ knowledge of statistical concepts, such as boxplots, which teachers were asked to use to adjust/impact their teaching. Pierce et al. (2014) showed teachers need more training in statistical use to develop fluency, and emphasized the importance of training addressing both attitudes and competence related to statistical literacy.

Guided Mastery Data Intervention	
Instructional Resource Reference(s)	Rogers, M. A. (2015). *A developmental study examining the value, effectiveness, and quality of a data literacy intervention*. (Publication No. 1767427384) [Doctoral dissertation, The University of Iowa]. ProQuest Dissertations & Theses Global.
What is Being Taught by the Instructional Resource	Data literacy dispositions (perceptions about data and self-efficacy) as well as knowledge and skills related to “the following

	data literacy domains: 1) conceptual understandings about data[,] 2) ability to accurately interpret data and draw appropriate inferences based on assessment information[, and] 3) ability to appropriately use multiple types of student data" (Rogers, 2015, p. 35); see Table 3 of publication for detailed information about the data concepts and skills
Appropriate Level(s)	Both advanced pre-service and early career in-service
How to Access/Use the Instructional Resource	Publication includes an outline of the training content, full pre- and post-training survey instruments, detailed descriptions of the training lessons and Educator Data Literacy Assessment (ELDA) including sample questions, sample teaching scenario from training lesson, and the ELDA full scoring rubric; the publication author would need to be contacted to access the full training lessons, data interpretation and use guide, training data file with a variety of simulated student data, and full EDLA measure.
Time Required for Resource Implementation	Approximately 3.5 hours for completion of study procedures including a pre-test, three data lessons, a post-test (same as the pre-test), and a post-training survey
Assessment(s)	• Pre- and post-training surveys to measure "[...]perceptions about data, data self-efficacy and data knowledge and skills prior to the intervention and examination of changes in these data constructs over time [...as well as] participant feedback about the training to identify opportunities for improvement" (p. 32). • "A data literacy instrument, referred to as the Educator Data Literacy Assessment (EDLA), was developed and used [... as a pre- and post-test to collect] information about [...] data knowledge, skills, and self-efficacy" (p. 34). The EDLA also includes self-assessment, rating items to measure self-efficacy or confidence working with data.
Summary	An online training, referred to as a guided mastery data training, was designed and implemented with pre-service teachers to improve perceptions about data and confidence working with data as well as data knowledge and skills related to data use in the classroom. The training included three data lessons consisting of "recorded lectures with complementary PowerPoint slides, tutorial and exercises" (p. 27) along with a data interpretation and use guide as well as a training data file with simulated student data that was used when completing data scenarios to create an

	authentic learning experience. In addition to a pre- and post-training survey, the online training involved the completion of a pre- and post-test using the EDLA data literacy instrument to measure data literacy knowledge and skills as well as confidence working with data or self-efficacy. The training lessons and EDLA were all computer-based. The training "enhanced study participants' data self-efficacy and perceptions about data" (p. 130). Additionally, the training led to some improvements in or evolution of data literacy knowledge and skills related to content validity, data interpretations based on assessment format/design, progress monitoring, citing data to support claims, and understanding of how to use assessment data for group comparisons as well as identifying individual student strengths and weaknesses; however, "there were still many areas that the training did not help to remediate [...such as] understanding of instructional validity, reliability and validity concepts, and how to apply these in practice" (p. 122).

Instructional Resources for Early Career In-Service Teachers

Professional Development Standardized Testing Data Intervention	
Instructional Resource Reference(s)	Hodes, C. L., Foster, J. C., Pritz, S. G., & Kelley, P. (2011). Structuring professional development with an online community. *Journal of Educational Technology Systems, 39*(3), 295-319. https://doi.org/10.2190/ET.39.3.f
What is Being Taught by the Instructional Resource	Data literacy knowledge and skills, specifically for using and interpreting data from standardized technical assessments in Career and Technology Education
Appropriate Level(s)	Early career in-service
How to Access/Use the Instructional Resource	Enough details in publication to understand the instructional resource, however would need to contact the publication author for the full instructional resource materials.
Time Required for Resource Implementation	1-day workshop followed by ongoing mentoring
Assessment(s)	• Initial questionnaire administered prior to the workshop/training to obtain a baseline measure of how "schools had used technical assessment data in previous years" (Hodes, Foster, Pritz, & Kelley, 2011, p. 302).

	• Measurement aligned to the workshop content standards and administered prior to the workshop/training, immediately after the workshop/training, and near the end of the project "to measure participants' learning and retention of using data for decision making. [...]The second and third assessments included an added performance component to the knowledge assessment, which consisted of an evaluation of the action plans for data use that participants develop during the training and the subsequent implementation of those plans in their school environment. [...]Retention was measured by the third administration of the assessment" (p. 302).
Summary	An online professional development program focused on increasing in-service teachers' ability to analyze standardized testing data. The professional development program included content on the analysis, interpretation, and application (including appropriate and inappropriate uses) of technical assessment results based on a five-step model "for an annual data cycle used by educators" (p. 301; see Figure 1 of the publication).

Teaching and Learning Analytics Tutorial	
Instructional Resource Reference(s)	Sampson, D. (2017). Teaching and learning analytics to support teacher inquiry. *2017 IEEE Global Engineering Education Conference (EDUCON)*. Athens, Greece: IEEE. doi: 10.1109/EDUCON.2017.7943109
What is Being Taught by the Instructional Resource	Data literacy knowledge and skills related to analytics technologies that support classroom teachers through the teacher inquiry process with a focus on data-based reflective practice "to holistically support teachers' reflective cycle and improve their teaching practice to the benefits of their students" (Sampson, 2017, p. 1182)
Appropriate Level(s)	Early career in-service
How to Access/Use the Instructional Resource	Publication describes the purpose of the tutorial, however the publication author would need to be contacted for the tutorial materials. "The tutorial is based on the material of the Massive Open Online Course (MOOC) Analytics for the Classroom Teacher developed and offer by the School of Education, Curtin University through the edX platform" (p. 1881), which is available

	for free via: https://www.edx.org/course/analytics-for-the-classroom-teacher.
Summary	The tutorial introduces the field of Teaching and Learning Analytics from the perspective of a classroom teacher, and discusses "how Educational Data Analytics can be used to support Teacher Inquiry and improve classroom-based teaching and learning" (p. 1881).

Data-Based Decision Making Intervention	
Instructional Resource Reference(s)	Staman, L., Timmermans, A. C., & Visscher, A. J. (2017). Effects of a data-based decision making intervention on student achievement. *Studies in Educational Evaluation, 55*, 58-67. http://dx.doi.org/10.1016/j.stueduc.2017.07.002
What is Being Taught by the Instructional Resource	Data-based decision making (DBDM) with a focus on the knowledge, skills, and attitudes needed to analyze and evaluate student data results, set goals to accomplish with their students that are SMART (Specific, Measurable, Attainable, Realistic, and Time-bound) and challenging, determine strategies for accomplishing the goals, and execute these planned strategies
Appropriate Level(s)	Early career in-service
How to Access/Use the Instructional Resource	Publication provides an overview of the Focus Intervention related to DBDM including the topics and activities for each intervention meeting (see Appendix A of the publication), however the publication author would need to be contacted for a copy of the materials used during the intervention.
Time Required for Resource Implementation	One year of training for teachers; two years of training for principals and academic coaches
Summary	The purpose of the Focus Intervention was to equip schools with the knowledge, skills, and attitudes needed to make systematic, data-based decisions at the classroom level (for teachers) and school level (for principals and academic coaches) based on half-year, interim assessments. The results led to tailored instruction for their students. For each school, the teachers, principal, and academic coach all participated in the Focus Intervention related to DBDM. The Focus Intervention protocol was based on the four components of the DBDM (see Figure 1 of the publication). Staman, Timmermans, and Visscher (2017) describe how:

	[s]chools were first taught to analyze student performance data with their student monitoring system. Next, they learned how to set student performance goals given what they had learned about their students' performance. In the following step, they were coached to design instructional approaches that were expected to be effective in accomplishing their goals. In the final step, teachers had to implement the tailor-made instructional plan in the classroom. After completing all the steps, teachers had to analyze students' progress (after half a year, when students took the next standardized test) and thereafter go through all the steps again. (p. 60) The effectiveness of the intervention was examined using student achievement data results and two student background characteristics variables (i.e., gender and socio-economic background based on level of parental education). The findings indicated no main effects from the intervention, but significant interaction effects were found where the intervention effects showed findings of "more positive for students with lower pre-test scores and students with lower socio-economic status" (p. 65).

School Feedback Project	
Instructional Resource Reference(s)	Vanhoof, J., Verhaeghe, G., Van Petegem, P., & Valcke, M. (2013). Improving data literacy in school: Lessons from the school feedback project. In K. Schildkamp, M. K. Lai, & L. Early (Eds.), *Data-based decision making in education* (pp. 113-126). New York: Springer. https://doi.org/10.3102/0002831216637346
What is Being Taught by the Instructional Resource	The School Feedback Project focused on the data literacy of educators, such as school principals, and addresses the question of how schools can be supported in their growth process towards the acquisition of data use-related knowledge, skills, and attitudes. It advocates for "initiatives at developing data-use competencies and having access to support can indeed make a contribution to improving these competencies" (Vanhoof, Verhaeghe, Van Petegem, & Valcke, 2013, p. 132).
Appropriate Level(s)	Early career in-service
How to Access/Use the Instructional Resource	The publication itself can be used as a resource given the study demonstrates the acknowledgement of the skills and competencies needed in order to make valuable use of data.

Summary	The School Feedback Project explores the use of data, the preconditions needed to make good use of data, and "how schools can be supported in their growth process towards the acquisition of data use-related knowledge, skills, and attitudes" (p. 113). It included a variety of supports, such as on-site training, study days, and peer consultation, related to the seven steps in school feedback use (receiving data, reading and discussing, interpretation, diagnosis, planning, implementation, and evaluation; see Figure 7.1 of the publication) that are involved in successful data use.

Section 3: Data Literacy, Statistical Literacy, & Graph Literacy Measures

The Measures section synthesizes available measures of data literacy, as well as statistical and graphic literacy developed for pre-service and/or in-service teachers. To meet criteria for inclusion in this section, the instruments must measure knowledge and skills; measures of beliefs, attitudes, and perceptions about data literacy were not included.

This section provides summary information for identified data literacy measures and is followed by summaries of measures of statistical literacy and graph literacy. The summary for each measure includes a description of the constructs measured, whether it has been used with pre-service and/or in-service teachers, evidence of reliability and/or validity (if available), and information on how to access the measure. Appendices B-F of this guide provide copies of the measures publicly available, as well as for measures whose author(s) granted permission to include in this Resource Guide.

The number of available measures is limited. Several authors noted that these measures should not be used by teacher preparation to make high-stakes decisions. Faculty members in teacher preparation programs who decide to use or adapt items from these measures should familiarize themselves with the measures' intended use, psychometric properties, strengths, and limitations. We encourage the data from these measures to inform instruction rather than be used as summative measures.

As you read the table for each measure, consider whether the:

- constructs measured align with those you want to measure
- measure was designed for the types of respondents you are working with (i.e., pre-service or in-service teachers)
- measure is easily accessible (see this guide's appendices and information in each measure's table row *How to Access/Use the Data Literacy Measure*)
- extent to which the measure's reliability and validity are established
- extent to which there might be value in administering the measure as a pre-/post-test or on a more frequent or formative basis to identify gaps in understanding and to further support pre-service or in-service teachers.

Data Teams Data Literacy	
Reference(s) for Interpretation and Use of the Measure	Ebbeler, J., Poortman, C. L., Schildkamp, K., & Pieters, J. M. (2017). The effects of a data use intervention on educator: Satisfaction and data literacy. *Educational Assessment, Evaluation and Accountability, 29*, 83-105. https://doi.org/10.1007/s11092-016-9251-z Ebbeler, J., Poortman, C. L., Schildkamp, K., & Pieters, J. M. (2016). Effects of a data use intervention on educators' use of knowledge and skills. *Studies in Educational Evaluation, 48*, 19-31. https://doi.org/10.1016/j.stueduc.2015.11.002 Kippers, W. B., Poortman, C. L., Schildkamp, K., & Visscher, A. J. (2018). Data literacy: What do educators learn and struggle with during a data use intervention? *Studies in Educational Evaluation, 56*, 21-31. https://doi.org/10.1016/j.stueduc.2017.11.001
Appropriate Level(s)	In-service teachers
Constructs measured by the Data Literacy Measure	Measures teachers' data literacy skills relevant to the data literacy tasks covered in the data team intervention for a study conducted in the Netherlands. The tasks addressed problem definition, data collection, formulating hypotheses, data quality check, data analysis, interpretation and conclusion, implementing improvement measures, and evaluation.
Types of Items	12 open-ended scenario questions analyzed by coding responses obtained through administration of a paper-and-pencil test; teachers provided 30 minutes to complete the items
Evidence of Validity and/or Reliability	0.92 Cohen's kappa (inter-rater agreement)
How to Assess/Use the Data Literacy Measure	The measures were developed in connection with the authors' data team™ procedure and assesses data literacy within this framework. The authors stated that they would have liked to administer a longer test for reliability purposes, but this was not possible within the scope of their intervention. They triangulated with other data such as interviews and a questionnaire, to assess gains from pre- to post intervention. In relation to this point, **please note the authors' comments**: ● "This test is explicitly NOT intended, nor suitable, to

	evaluate teachers individually. The test was developed to use in a pre-assessment post-assessment research approach with a data team procedure (with external coaching) following the pre-assessment. It can be used as a pre-assessment to identify what teachers mostly struggle with to identify further professional development needs (analyzed at an aggregated level), or for research purposes triangulated with other data, but NOT to assess teachers individually for evaluation purposes." (Poortman, personal communication, July 1, 2020) ● For more information about the data team procedure see: https://www.springer.com/gp/book/9783319588520 **Available in this guide's appendix?** Yes, see Appendix B, Data Teams Data Literacy

Data Scenario Interview Form	
Reference(s) for Interpretation and Use of the Measure	Means, B., Chen, E., DeBarger, A., & Padilla, C. (2011). *Teachers' ability to use data to inform instruction: Challenges and supports*. U.S. Department of Education. https://www2.ed.gov/about/offices/list/opepd/ppss/reports.html
Appropriate Level(s)	In-service teachers
Constructs measured by the Data Literacy Measure	Teachers' data use skills are measured in the following abilities: Find the relevant pieces of data in the data system or display available to them (*data location*), understand what the data signify (*data comprehension*), figure out what the data mean (*data interpretation*), select an instructional approach that addresses the situation identified through the data (*instructional decision making*), [and] frame instructionally relevant questions that can be addressed by the data in the system (*question posing*). (p. viii)
Types of Items	7 data scenarios; individual teachers and small groups respond to scenarios during interviews; responses are coded and analyzed
Evidence of Validity and/or Reliability	Developed for use in exploratory study; no evidence of instrument validity or reliability provided in report
How to Assess/Use the Data Literacy Measure	This public domain report is a sub-study from the *Study of Education Data Systems and Decision Making*. The items used in the study were included in the full text report at the link below (pp.

	70-102). A resource guide for providing teacher professional development on data use to inform instruction is included in the report and links each of the seven scenarios to the skills addressed and response analyses guidance for facilitators. https://files.eric.ed.gov/fulltext/ED516494.pdf **Available in this guide's appendix?** No, see Piro et al. (2014) for adapted versions of scenarios

Data Literacy Pre/Post-Test of Content on Data Literacy Behaviors	
Reference(s) for Interpretation and Use of the Measure	Dunlap, K., & Piro, J. S. (2016). Diving into data: Developing the capacity for data literacy in teacher education, *Cogent Education, 3,* 2-13. https://doi.org/10.1080/2331186X.2015.1132526 Piro, J. S., Dunlap, K., & Shutt, T. (2014). A collaborative Data Chat: Teaching summative assessment data use in pre-service teacher education. *Cogent Education, 1,* 1-24. https://doi.org/10.1080/2331186X.2014.968409
Appropriate Level(s)	Pre-service teachers
Constructs measured by the Data Literacy Measure	The items in the measure were adapted from the Means et al. (2011) report, which was discussed in the previous table. The pre/post-test of content on data literacy behaviors included nine data literacy behaviors for using tables, graphs, histograms, or test score displays. These nine behaviors are (Piro et al., 2014): 1) data location, 2) comparing and manipulating numbers in a table or graph, 3) moving fluently between alternative representations of data, 4) interpreting a histogram, 5) manipulates data from a complex graph to support reasoning, 6) moves fluently between different representations of data, 7) examining score distributions, 8) providing differentiated instruction based on data, and 9) appreciates impact of extreme scores on the mean. (p. 8)
Types of Items	A 10-item quantitative measure of content on data literacy behaviors requiring respondents to use displays of data to answer open-ended questions collected through a survey.

Evidence of Validity and/or Reliability	Developed for use in exploratory study; no evidence of instrument validity or reliability provided in report (see Means et al., 2011)
How to Assess/Use the Data Literacy Measure	Table 3 (page 8) in Piro, Dunlap, and Shutt (2014) publication https://doi.org/10.1080/2331186X.2014.968409 **Available in this guide's appendix?** Yes, see Appendix C, Pre/post-test of Content on Data Literacy Behaviors

NU Data Knowledge Scale	
Reference(s) for Interpretation and Use of the Measure	Doll, B., Horn, C., & Shope, R. (2010). *NU data: Using data to foster the school success of students with disabilities* (pp. 1-25). Institute of Educational Sciences. https://ies.ed.gov/funding/grantsearch/details.asp?ID=1131 Sikorski, J. D. (2016). *Examination of the NU Data Knowledge Scale*. (Publication No. 10125684) [Doctoral dissertation, University of Nebraska]. ProQuest Dissertations & Theses Global.
Appropriate Level(s)	Pre-service and in-service teachers
Constructs measured by the Data Literacy Measure	Doll and colleagues (2005) identified basic skills that teachers need to improve their data-based decision making. Referred to as databasics, these skills include: "1) knowledge of diverse data collection protocols; 2) selecting protocols best suited to answer teachers' questions; 3) collating and graphing data; 4) discerning trends and differences in data; 5) using data in team problem-solving; and 6) selecting evidence-based interventions" (Sikorski, 2016, p. 17).
Types of Items	30 multiple choice questions
Evidence of Validity and/or Reliability	TKR-20 value of 0.61 (below 0.70 acceptable level for high stakes decisions, though acceptable for a new measure in preliminary studies). Subject matter experts' absolute agreement on items ranged from 79.4 to 81.7.
How to Assess/Use the Data Literacy Measure	**Available in this guide's appendix?** Yes, see Appendix D, NU Data Knowledge Scale

Statistical and/or Graph Literacy Measures

Comprehensive Assessment of Outcomes in a first Statistics Course (CAOS) Test	
Reference(s) for Interpretation and Use of the Measure	Groth, R., & Bergner, J. (2013). Mapping the structure of knowledge for teaching nominal categorical data analysis. *Educational Studies in Mathematics, 83*, 247-265. https://doi.org/10.1007/s10649-012-9452-4 Original sources for more detail: Assessment Resource Tools for Improving Statistical Thinking Delmas, R., Garfield, J., Ooms, A., & Chance, B. (2007). Assessing students' conceptual understanding after a first course in statistics. *Statistics Education Research Journal, 6*(2), 28-58. http://iase-web.org/documents/SERJ/SERJ6(2)_delMas.pdf
Appropriate Level(s)	Pre-service teachers after any first course in statistics
Constructs measured by the Data Literacy Measure	The CAOS measures statistical literacy and conceptual understanding, with a focus on reasoning about variability. For a complete list of the measured learning outcomes, see Appendix A in Delmas, Garfield, Ooms and Chance (2007).
Types of Items	40 item multiple-choice that typically require 30 to 45 minutes for students to complete
Evidence of Validity and/or Reliability	Cronbach's alpha coefficient of 0.78
How to Assess/Use the Data Literacy Measure	To administer the CAOS test, register here: https://apps3.cehd.umn.edu/artist/tests/register.asp **Available in this guide's appendix?** No

New Test for Reading and Understanding Learning Progress Assessments (LPAs)	
Reference(s) for Interpretation and Use of the Measure	Zeuch, N., Forster, N., & Souvignier, E. (2017). Assessing teachers' competencies to read and interpret graphs from Learning Progress Assessment: Results from tests and interviews. *Learning Disabilities Research & Practice, (32)*1, 61-70. https://doi.org/10.1111/ldrp.12126
Appropriate Level(s)	Pre-service and in-service teachers

Constructs measured by the Data Literacy Measure	In Germany, learning progress assessment (LPA) is a formative assessment approach similar to curriculum-based measurement (CBM). LPAs provide graphs of students' formative data used to assist teachers with data-based decision making. Zeuch et al. (2017) developed the New Test for Reading and Understanding Learning Progress Assessment, referred to as the New LPA-Test, for assessing in-service teachers' graph literacy, specifically related to LPA graphs. Graph literacy is defined as the ability to: "1) read the data (find specific information in the graph), 2) read between the data (recognize and describe relationships), and 3) read beyond the data (make inferences and predictions based on the data)" (Zeuch, Forster, & Souvignier, 2017, p. 62).
Types of Items	The New LPA-Test asks respondents to rate on a 7-point Likert scale how well a statement accurately describes information depicted on each of eight line graphs. Estimated administration time of 40 minutes to complete the entire test.
Evidence of Validity and/or Reliability	Internal consistency (Cronbach's Alpha 0.74 - 0.79)
How to Assess/Use the Data Literacy Measure	**Available in this guide's appendix?** Yes, see Appendix E, LVD-Test (English). Please note, the original version was developed in German. Appendix E includes an English translation of the measure (provided by original authors).

Pre-/Post-Questionnaires for a Science Methods and a Mathematics Methods Course	
Reference(s) for Interpretation and Use of the Measure	Morrison, J., & Roth McDuffie, A. (2009). Connecting science and mathematics: Using inquiry investigations to learn about data collection, analysis, and display. *School Science and Mathematics, 109*(1), 31-44. https://doi.org/10.1111/j.1949-8594.2009.tb17860.x
Appropriate Level(s)	Pre-service teachers
Constructs measured by the Data Literacy Measure	The science methods pre- and post-questionnaire assessed understanding about developing investigable questions, experimental design, independent and dependent variables, and drawing conclusions based on empirical evidence. The mathematics methods pre- and post-questionnaire measured comprehension of common graphs (e.g., circle, graph, scatter

	plot, line plot, box and whisker graph, bar graph, line graph, and stem and leaf graph) and creating data displays.
Types of Items	The science questionnaire presented an experiment, its results, and at least five open-ended questions. The mathematics questionnaire consisted of 10 data visualizations. Respondents were asked to rate their familiarity with each one, describe their interpretation, explain the variables being represented, the kinds of information included in the data visualization, and anything else they knew about the type of data visualization.
Evidence of Validity and/or Reliability	No evidence of validity or reliability provided in publication
How to Assess/Use the Data Literacy Measure	Sample questions are provided in Morrison and Roth McDuffie's (2009; Appendix B) publication. **Available in this guide's appendix?** No

Graph Literacy Survey	
Reference(s) for Interpretation and Use of Measure	Oslund, E. L., Elleman, A. M., & Wallace, P. K. (accepted for publication). Factors related to data-based decision making: Examining experience, professional development, and the mediating effect of confidence on teacher graph literacy. *Journal of Learning Disabilities.* Wallace, P. K. (2019). *Teachers' knowledge and implementation of response to intervention practices: Graph literacy and data-based decision making*. (Publication No. 13857437) [Doctoral dissertation, Middle Tennessee State University]. ProQuest Dissertations & Theses Global.
Appropriate Level(s)	In-service teachers and administrators
Constructs measured by the Data Literacy Measure	The graph literacy survey asks respondents to review data depicted in progress monitoring graphs to determine if current interventions are effective, and whether the student should be re-assigned to more or less intensive interventions. Graphs and multiple choice questions provided option choices varying from three to nine choices. Graphs included information measuring respondents' understanding of trend lines.
Type of Items	Graphs depicted data with multiple choice questions

Evidence of Validity and/or Reliability	Cronbach's alpha was 0.71 (acceptable)
How to Assess/Use the Data Literacy Measure	Measure is provided in the Wallace's (2019) dissertation appendices (pp. 87-97). **Available in this guide's appendix?** Yes, see the Data Literacy Measures Guide's Appendix F

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Appendix A: Additional Instructional Resources

As referenced in Section 2: Instructional Resources for Teaching Data Literacy and Statistical Literacy to Pre-Service and Early Career In-Service Teachers, this appendix includes instructional resources that were not identified through the systematic literature review process (e.g., because the resource is a website not described in a publication), however offer valuable materials that could be utilized to teach data literacy and/or statistical literacy. Below each additional instructional resource is a brief description of the resource in relation to teaching data literacy and/or statistical literacy.

Data Quality Campaign (DQC): https://dataqualitycampaign.org/

> DQC strives to ensure that everyone with a stake in education—especially families and educators—can access and use quality student data to raise achievement for all students. We are the nation's foremost organization advocating for effective data policy and use. DQC strives to ensure that everyone with a stake in education—especially families and educators—can access and use quality student data to raise achievement for all students. We are the nation's foremost organization advocating for effective data policy and use. (Data Quality Campaign, 2020, Who we are section, para. 1)

Data Literacy 101: https://dataqualitycampaign.org/resource/data-literacy-101/

> "This page showcases resources that leaders at every level can use to build their understanding of data literacy, and the actions that must be taken to meet the needs of educators and make data use a more seamless part of the school day and year" (Data Quality Campaign, 2019, Data literacy 101 section, para. 1).

Mandinach, E. B. (2017, April 14). *Data literacy is more than just test results: Why it is important in early childhood education*. National Institute for Early Education Research (NIEER). http://nieer.org/2017/04/14/data-literacy-just-test-results-important-early-childhood-education

> Blog post by Mandinach on the NIEER website related to data literacy and early childhood education, which discusses the definition of data literacy, the uses of data in early childhood education as well as its importance, and five recommendations for effective data use.

National Center on Intensive Intervention (NCII): www.intensiveintervention.org

> [National Center on] Intensive intervention helps students with severe and persistent learning and behavioral needs, including students with disabilities. It is a process, not a specific program or product. The process is driven by data, characterized by increased intensity and individualization, and considers the academic and behavioral needs of the student. In some schools, intensive intervention may be known as "Tier 3 intervention," and may be embedded within a multi-tiered system of support (MTSS) framework. (National Center on Intensive Intervention, n.d., Intensive Intervention section, para. 1)

> NCII's approach to intensive intervention is Data-based Individualization or DBI. DBI is a

research-based process for individualizing and intensifying interventions through the systematic use of assessment data, validated interventions, and research-based adaptation strategies. DBI is the technical term for what many good teachers do naturally through the problem-solving process: frequently review student data and make changes to their teaching based on what works for students. DBI, however, makes this process systematic, explicit, and tailored to meet the needs of individual students through a multi-step process that gradually intensifies instruction and support. (National Center on Intensive Intervention, n.d., Intensive intervention section, paras. 2-3)

NCII's Taxonomy of Intervention Intensity:

https://intensiveintervention.org/taxonomy-intervention-intensity

The *Taxonomy of Intervention Intensity* (Fuchs, Fuchs, & Malone, 2017) can be used to select or evaluate an intervention platform used as the validated intervention platform or the foundation of the DBI process. It can also be used to guide the adaptation of intensification of an intervention during the intervention adaptation step of the DBI process. (National Center on Intensive Intervention, n.d., Taxonomy of intervention intensity section, para. 1)

NCII Hypothesis Generation:

https://intensiveintervention.org/sites/default/files/Clarifying_Questions_Hypothesis_508.pdf

"This resource includes questions that teams can use to develop a hypothesis about why an individual or group of students may not be responding to an intervention" (National Center on Intensive Intervention, n.d., Hypothesis generation section, para. 1).

NCII Resources to Support the Teaming Process:

https://intensiveintervention.org/implementation-support/tools-support-intensive-intervention-data-meetings

"This resource from NCII and the PBIS Center, provides information about how DBI can support [individualized education program or] IEP implementation and provides a table with key considerations for teams working across the MTSS system" (National Center on Intensive Intervention, n.d., Resources to support the teaming section, para. 2).

NCII Lessons Learned:

https://intensiveintervention.org/resource/supporting-implementation-data-based-individualization-lessons-learned-nciis-first-five

"The purpose of this document is to provide an overview of the Center's accomplishments and to highlight a set of lessons learned from the 26 schools that implemented intensive intervention while receiving technical support from the Center" (National Center on Intensive Intervention, n.d., Lessons learned section, para. 1).

NCII Voices from the Field: https://intensiveintervention.org/voices-from-the-field/

> "This section spotlights experiences and lessons learned from those implementing intensive intervention in schools, districts, states, and teacher preparation programs as well as new research related to intensive intervention and data-based individualization (DBI)" (National Center on Intensive Intervention, n.d., Voices from the field section, para. 1).

NCII Virtual Resources:

https://intensiveintervention.org/resource/using-sample-lessons-support-continuity-learning

This series includes video examples and tip sheets to help educators and families in using the NCII reading and mathematics sample lessons to support students with intensive needs. These lessons provide short instructional routines to encourage multiple practice opportunities using explicit instruction principles. The videos and tip sheets describe how educators can use the sample lessons to support instruction in a virtual setting, how educators can share these lessons with parents, and how parents can also implement the lessons to provide additional practice opportunities. (National Center on Intensive Intervention, n.d., Virtual resources section, para. 1)

NCII Academic Goal Setting Guide:

https://intensiveintervention.org/resource/high-quality-academic-IEP-goals

In this guide, we explain how educators can establish IEP goals that are measurable, ambitious, and appropriate in light of the student's circumstances. Four important steps are required for setting a valid goal for individual student performance: selecting a measure, establishing baseline performance, choosing a strategy for setting the goal, and writing a measurable goal. Although this guide presents the steps that educators can take to set appropriate IEP goals, all members of the IEP team, including families, should be involved in discussions about setting the goal. (National Center on Intensive Intervention, n.d., Academic goal setting guide section, para. 2)

NCII Behavioral Goal Setting Guide:

https://intensiveintervention.org/resource/high-quality-behavior-IEP-goals

> "The purpose of this guide is to provide an overview of behavioral progress monitoring and goal setting to inform data-driven decision making within tiered support models and individualized education programs (IEPs)" (National Center on Intensive Intervention, n.d., Behavioral goal setting guide section, para. 1).

FAQ on Virtual Progress Monitoring:

https://intensiveintervention.org/resource/FAQ-collecting-progress-monitoring-data-virtually

Progress monitoring is an essential part of a multi-tiered system of supports (MTSS) and, specifically, the data-based individualization (DBI) process. It allows

educators and administrators to understand whether students are responding to intervention and if adaptations are needed. In addition, these data are often used to set high-quality academic and behavioral goals within the individualized education program (IEP) for students with disabilities. With the closure of schools due to the COVID-19 pandemic, educators and administrators need to rethink how they collect and analyze progress monitoring data in a virtual setting. This collection of frequently asked questions is intended to provide a starting place for consideration. (National Center on Intensive Intervention, n.d., Virtual progress monitoring section, para. 1)

Sign up for the NCII newsletter: https://intensiveintervention.org/contact

WestEd. (2020). *Data literacy assessments*.
https://datafordecisions.wested.org/data-use-in-action/data-literacy-assessments/
The Data Literacy Assessments Project at WestEd, in collaboration with Using Data Solutions, has produced four scenario-based exercises that can be used to measure data literacy. The materials can be used as assessments, as supplemental instructional materials to develop data literacy for educational professionals in professional development or college and graduate courses, and for research purposes. The scenarios are designed to depict typical instances when teachers need to use data to make decisions in the course of their practice or personal experiences. They will allow users to demonstrate a variety of data literacy skills as outlined in the construct Data Literacy for Teachers (DLFT) developed by Ellen Mandinach and Edith Gummer. (Data Decisions for WestEd, n.d., Data literacy assessment section, para.1)

WestEd's Data for Decisions Tools & Resources:
https://datafordecisions.wested.org/tools-resources/
"This page offers a series of professional tools and resources that educators can use to better implement data use in their classrooms, schools, and districts" (WestEd, 2020, Tools & Resources section, para. 2).

Appendix B: Data Teams Data Literacy

Credit:

Ebbeler, J., Poortman, C. L., Schildkamp, K., & Pieters, J. M. (2017). The effects of a data use intervention on educator: Satisfaction and data literacy. *Educational Assessment, Evaluation and Accountability, 29,* 83-105. https://doi.org/10.1007/s11092-016-9251-z

Ebbeler, J., Poortman, C. L., Schildkamp, K., & Pieters, J. M. (2016). Effects of a data use intervention on educators' use of knowledge and skills. *Studies in Educational Evaluation, 48,* 19-31. https://doi.org/10.1016/j.stueduc.2015.11.002

Kippers, W B., Poortman, C. L., Schildkamp, K., & Visscher, A. J. (2018). Data literacy: What do educators learn and struggle with during a data use intervention? *Studies in Educational Evaluation, (56*), 21-31. https://doi.org/10.1016/j.stueduc.2017.11.001

Data Teams Data Literacy

(English translation)

Question 1. **A data team would like to investigate poor STAAR results for Park Street Middle School students in the 7th grade. To start, the team needs to determine the scope of the problem. How will the team be able to 'prove' that the results for PSMS students in the 7th grade are really a problem?**

- *1 point for 'data collection* or *making an overview'*
- *1 extra point for 'STAAR results 7th grade' (only if also first point)*
- *1 extra point for 'more than 1 cohort/year group' (only if also first point)*
- Max 3 points for this question

Question 2. **A data team wants to focus on low mathematics student achievement in Grade 6. They think the quality of the mathematics education in elementary education is the cause of the low student achievement results in Grade 6. Describe two data sources than can be used by the data team to find out whether their hypothesis is correct.**

- *1 point for each relevant data source, e.g. test scores mathematics Grade 6; mathematics book and assignments. Sources need to be formulated concretely, e.g. not just 'the book', or 'the marks'.*
- Max 2 points

Question 3. **A data team wants to focus on the problem regarding low student achievement results in English language arts. The results are particularly low in the school years 2014-15, 2015-16, and 20162017. Formulate a hypothesis about a possible cause of this problem.**

- *Formulated like a hypothesis about the cause of the problem:*
- *1 point for plausible cause*
- *1 point for concrete (i.e. target group, educational track)*
- *1 point for measurable*
- *Max 3 points*

Question 4. **A mathematics data team has implemented the instructional action that every lesson in the 8th grade will begin with a short review lesson on 'measurement.' The team would like to evaluate how the action was implemented and is perceived by teachers. Specifically, they want to answer the question "How do colleagues perceive this action?" Describe two instruments/measures that can be used to answer this question.**

1. *(group) interviews teachers*
2. *Teacher questionnaire*
3. *Teacher logs*

- *0,5 point for each relevant instrument*
- *0 points for just 'data collection'*
- *Max 1 point*

Question 5. **A data team wants to analyze whether a professional development course for teachers about differentiating in the classroom has resulted in higher student achievement results for the subject of Science. Use the data table below and describe how you would analyze the data. (***Please note that the table only presents a selection of the data)*

Student	Score before teacher followed the course (out of 10)	Score after teacher followed the course (out of 10)
Mary	7.0	6.5
Clarke	5.0	6.5
John	4.5	5.0
Tiara	6.0	7.0
Lisa	4.0	5.5
Carlos	7.0	6.5

After-score is higher on average (0,8), and the spread is lower. The difference between the students has decreased. There is also only one student left with an insufficient score (5,0).

- *1 point for each relevant analysis, e.g. comparison of averages, spread, and number of insufficient.*
- *No points for statements like 'Mary has one half point lower after the teacher has taken the course'.*
- *Max 3 points*

Question 6. **Data have to be of a sufficient quality to support conclusions about the problem. List two data quality criteria and explain each.**

- *Reliability and validity*
- *0.5 points for only reliability or validity, 1 point if any of these is explained correctly. 0.25 points for only aspects of reliability, e.g. 'sufficient amount of data'.*
- *Completeness, relevance and recentness, and objectivity are also mentioned in the manual and can be awarded 1 point.*
- Max 2 points in total

Question 7. **A team has completed the first six steps of the data use intervention. Analysis of the data suggests that teachers do not provide enough feedback about students' learning, and that this is one of the causes of disappointing results for Mathematics in the 8th grade. The team wants to start with step 7: implementing an instructional action. Name two concrete possible actions that align to the cause of the problem.**

For example:

1. *workshop and/or course about providing feedback for teachers*
2. *teachers observing each other and discussing feedback in the classroom*
3. *providing (and discussing application of) literature about feedback for teachers*

- *1 point for describing a measure – this is not about further investigation, but a concrete action*
- *Max 2 points*

Question 8. **Compose a problem statement based on the following table of collected data.**

Science Benchmark Exam	**7th grade Average score (out of 10)**	**8th grade Average score (out of 10)**
Cohort (year group/class) 1	6.1	5.6
Cohort 2	6.3	5.2
Cohort 3	5.8	5.1
Average, Cohorts 1-3	**6.1**	**5.3**

1 point for sentence one, 1 point for sentence two, 1 point for sentences three and four

a. *Sentence one: subject, target group are included*
b. *Sentence two: period and scope of problem are given*
c. *Three and four: measurable goal for next two school years are included.*

- Max 3 points

Question 9. **A data team would like to investigate the problem of disappointing results for mathematics in 6th grade. All team members have the assignment of formulating one (qualitative) research question to study in relation to this problem. Formulate one concrete research question the team could study.**

- *Formulated as a research question for qualitative study (How, What, Why…)*
- *1 point for plausible*
- *1 point for concrete (e.g. target group and subject)*
- *Max 2 points*

Case: Poor results 8th grade English Language Arts

Questions 10-12 are all about this case

A data team thinks the results for English Language Arts in 8th grade are disappointing. The team decides to investigate the results in terms of areas within this subject (e.g., oral proficiency of students). The numbers in this table represent results in a class of 30 students.

Subject area category	Number of students who failed portions of the benchmark exam related to this subject-area
Oral proficiency	**3**
Writing skills	**10**
Reading skills	**6**

Question 10. **For the last three school years, the percentages of students who failed these portions of the benchmark exam have been consistent (see the table above) across 8th grade sections of ELA. Which conclusions can you take, based on these data? Answer in a maximum length of five sentences.**

- *Mostly writing skills seem to be the cause (10/30 students = 33%; compared to 3/30 students = 10% and 6/30 students = 20%)*
- *No points for random conclusions, such as 'the book does not focus on writing skills sufficiently'*
- 1 point for sufficient description of conclusion
- *Max 1 point*

Question 11. **Describe a concrete strategy to improve low student achievement results in 8th grade ELA (see above). Answer in a maximum length of five sentences.**

Strengthen instruction in the area of writing skills, for example by: professional development for teachers in this area, expanding time for this area in the lesson schedule, more attention for practicing writing skills and/or a better learning book.

- *1 point for description of an action*
- *Max 1 point*

Question 12. **Describe how you could evaluate whether the strategy you identified in Question 11 has successfully addressed the problem regarding low 8th grade ELA results.**

After having implemented the action (and sufficient time has passed), collect data about the results for Dutch – writing skills in this grade and evaluate whether these have improved.

- *2 points for description of relevant and appropriate evaluation.*
- No points for only 'evaluation' or 'posttest'.
- *Max 2 points*

Max 25 points in total

Appendix C: Pre/Post-Test of Content on Data Literacy Behaviors

Credit:

Piro, J. S., Dunlap, K., & Shutt, T. (2014). A collaborative Data Chat: Teaching summative assessment data use in pre-service teacher education *Cogent Education, 1,* 1-24. https://doi.org/10.1080/2331186X.2014.968409

Piro, Dunlap, and Shutt (2014) adapted their data literacy behaviors from a 2011 U.S. Department of Education publication. The reference for the 2011 U.S. Department of Education publication is:

Means, B., Chen, E., DeBarger, A., & Padilla C. (2011). *Teachers' ability to use data to inform instruction: Challenges and supports*. U.S. Department of Education, Office of Planning, Evaluation and Policy Development, Washington, D.C. https://www2.ed.gov/rschstat/eval/data-to-inform-instruction/report.pdf

Pre/Post-Test of Content on Data Literacy Behaviors

Quantitative Data: Pre/Post Test of Data Literacy Behaviors

Data Literacy Behavior 1: Data Location

Grades 3–5 Students' Mathematics Scores, by Gender and Ethnicity

(Hypothetical Data)

						Number Students at Each Proficiency Level			
Grade	Gender	Ethnicity	Number of Students Tested	Percent of Tested Students	Mean Scale Score	Below Basic	Basic	Proficient	Advanced
3	Female	African American	1	1%	589	0	0	0	1
		Asian/Pac Islander	18	26%	444	5	4	6	3
		Latino	17	24%	428	6	5	5	1

		White	34	49%	449	4	12	12	6
		Total Female	70	100%	445	15	21	23	11
	Male	African American	2	3%	452	0	1	0	1
		Asian/Pac Islander	18	23%	450	3	6	6	3
		Latino	31	40%	430	8	7	14	2
		White	27	35%	448	6	11	7	3
		Total Male	78	100%	440	17	25	27	9
4	Female	African American	2	3%	462	1	0	1	0
		Asian/Pac Islander	20	26%	472	2	7	8	3
		Latino	18	24%	441	3	8	5	2
		White	36	47%	436	8	12	12	4
		Total Female	76	100%	447	14	27	26	9
	Male	African American	0	0%	NA	0	0	0	0
		Asian/Pac Islander	16	23%	442	2	8	5	1
		Latino	24	35%	438	3	13	5	3

		White	29	42%	456	5	12	10	2
		Total Male	69	100%	446	10	33	20	6
5	Female	African American	1	1%	317	1	0	0	0
		Asian/Pac Islander	35	32%	470	6	6	8	6
		Latino	22	29%	452	4	7	8	3
		White	22	37%	470	5	8	10	5
		Total Female	80	100%	463	14	21	26	14
	Male	African American	3	4%	560	0	0	1	2
		Asian/Pac Islander	18	26%	458	4	5	5	4
		Latino	16	24%	449	2	5	6	3
		White	31	46%	464	4	12	13	2
		Total Male	68	100%	462	10	22	25	11

Question: What was the mean (or average) scale score for the Asian/Pacific Islander fourth-grade girls who took the test?

Answer: 472

Data Literacy Behavior 2: Comparing and Manipulating Numbers in a Table or Graph

Grade 3 Student Reading Proficiency

(Hypothetical Data)

Question: Based on this chart, what percentage of the school's third-graders were less than proficient in reading?

Answer: About 65%

(See image below. Answer in space provided below.)

Data Literacy Behavior 3: Moving Fluently Between Alternative Representations of Data

Achievement in Grade 8 Mathematics

(Hypothetical Data)

Group	Number of students	Group mean math score	Number of students proficient	Percentage proficient
Latino	239	38.5	143	60
African American	52	36.5	25	48

Question: According to these data, were more than half of the school's eighth-graders were proficient in eighth-grade math?

Answer:

Data Literacy Behavior 4: Interpreting a Histogram

Grade 3 Reading Achievement Scores Over Three Years

(Hypothetical Data)

Question: Are there any errors in this histogram?

(See image below. Answer in space provided below.)

Answer: A close look at the histogram would reveal that the percentage of students in below basic, basic, proficient, and advanced categories adds up to more than 100.

Data Literacy Behavior 5: Manipulates data from a complex graph to support reasoning

Grade 3 Reading Achievement Scores Over Three Years

(Hypothetical Data)

Question: What was the difference in the district's total reading score in 2005–06 compared to

2003–04?

Are there any errors in this histogram?

(See image below. Answer in space provided below.)

Answer: A point or two higher" or "about the same.

Data Literacy Behavior 6: Moves fluently between different representations of data

Grade 3 Reading Achievement Scores Over Three Years

(Hypothetical Data)

Question: Compared to the district, Lake Forest School third-graders have been making progress in their reading **comprehension** skills over the three-year period. Agree or disagree?

(See image below. Answer in space provided below.)

Answer: Disagree

Data Literacy Behavior 7: Examining Score Distributions

Student Scores on an End-of-Unit Examination

(Hypothetical Data)

Student	Total score* (%correct)
Aaron	96
Anna	72
Beatrice	92
Bennie	68
Caitlin	92
Chantal	68
Crystal	100
Denny	88
Jaimie	68

Kayti	84
Mickey	68
Noah	96
Patricia	60
Robbie	72
Sofia	84
Stuart	68
Teresa	76
Tyler	68
Victor	100
Zoe	92
Class mean	**80.6**

*Percentage of test items the student answered correctly

Question 5: Would you agree with a colleague who said that they should move on to the next topic in the curriculum because the class mean on the unit test was 80 percent?

(See image below. Answer in space provided below.)

Answer: Express a need to examine individual student scores rather than rely on the class mean.

Data Behavior 8: Providing Differentiated Instruction Based on Data

Student Test Scores on Class Measurement Test

(Hypothetical Data)

Student number	Length (% correct)	Weight (% correct)	Volume (% correct)	Perimeter and area (% correct)	Total score (% correct)
1	99	95	89	100	96
2	89	77	60	45	68
3	100	100	72	97	92
4	87	91	56	32	67
5	97	78	100	83	90
6	92	95	73	43	76
7	100	100	100	100	100
8	100	100	92	74	92
9	80	80	60	56	69
10	87	100	75	50	78

Question: "Suppose that your students' performance on the various portions of the examination broke down as shown here. If you were the teacher, what would you do?"

(See image below. Answer in space provided below.)

Possible Answers: 1. set up one group of students for more instruction on vocabulary skills, while another group would be given lower-level texts and provided with intensive instruction on reading strategies. 2. pairing students who were struggling with reading with good readers or bringing in reading specialists for one-on-one intervention. 3. groups were very flexible and that a particular student could be in a high group for one skill but in a low group for another. As students progressed, more formative assessment would be given, and students could be moved in and out of a particular group throughout the year. 4. others

Data Behavior 9: Providing Differentiated Instruction Based on Data

Student Performance on State and Classroom Reading Tests

(Hypothetical Data)

	2006–07 State achievement test scale score			Fall 2007 class test score	
Student	**Total reading**	**vocabulary**	**comprehension**	**Sight reading**	**Text comprehension**
Aaron	393	375	410	16	5
Anna	530	510	550	24	7
Beatrice	498	505	490	22	8
Bennie	528	515	540	26	9
Caitlin	645	660	630	28	12
Chantal	513	515	510	20	10
Crystal	573	560	585	24	10
Denny	588	566	610	20	6

Jaimie	555	550	560	25	10
Kayti	541	553	528	26	9
Mickey	410	395	425	16	5
Noah	693	678	700	30	11
Patricia	416	400	432	20	7
Robbie	563	580	545	26	8
Sofia	480	500	460	22	10
Total possible	700	700	700	30	12
Class average	530	527	532	23	8

Question: "What, if anything, do these data tell you about how you might want to differentiate instruction for different students in your class?"

(See image below. Answer in space provided below.)

Answer: The above should suggest that teachers are more likely to think about differentiating instruction when provided with individual student-level data broken down by concept.

Data Literacy Behavior 10: Appreciates impact of extreme scores on the mean

Score Levels—Mathematics

						Number Students at Each Proficiency Level			
Grade	Gender	Ethnicity	Number of Students Tested	Percent of Tested Students	Mean Scale Score	Below Basic	Basic	Proficient	Advanced

3	Female	African American	1	1%	589	0	0	0	1
		Asian/Pac Islander	18	26%	444	5	4	6	3
		Latino	17	24%	428	6	5	5	1
		White	34	49%	449	4	12	12	6
		Total Female	70	100%	445	15	21	23	11
	Male	African American	2	3%	452	0	1	0	1
		Asian/Pac Islander	18	23%	450	3	6	6	3
		Latino	31	40%	430	8	7	14	2
		White	27	35%	448	6	11	7	3
		Total Male	78	100%	440	17	25	27	9
4	Female	African American	2	3%	462	1	0	1	0
		Asian/Pac Islander	20	26%	472	2	7	8	3
		Latino	18	24%	441	3	8	5	2
		White	36	47%	436	8	12	12	4
		Total Female	76	100%	447	14	27	26	9
	Male	African American	0	0%	NA	0	0	0	0

		Asian/Pac Islander	16	23%	442	2	8	5	1
		Latino	24	35%	438	3	13	5	3
		White	29	42%	456	5	12	10	2
		Total Male	69	100%	446	10	33	20	6
5	Female	African American	1	1%	317	1	0	0	0
		Asian/Pac Islander	35	32%	470	6	6	8	6
		Latino	22	29%	452	4	7	8	3
		White	22	37%	470	5	8	10	5
		Total Female	80	100%	463	14	21	26	14
	Male	African American	3	4%	560	0	0	1	2
		Asian/Pac Islander	18	26%	458	4	5	5	4
		Latino	16	24%	449	2	5	6	3
		White	31	46%	464	4	12	13	2
		Total Male	68	100%	462	10	22	25	11

Question: Overall, based on the Grade 3 data in this table, would you say that there was a difference between boys and girls in mathematics test performance?

(See image below. Answer in space provided below.)

Answer: Points out the extremely high score of the African-American third-grade girl as likely pulling up the girls' mean.

The above pre/post intervention test was adapted from:

Means, B., Chen, E., DeBarger, A., & Padilla, C. (2011). Teachers' ability to use data to inform instruction: Challenges and supports. Washington, DC: Author, Office of Planning, Evaluation and Policy Development, US Department of Education.

5.1 What was the mean (or average) scale score for the Asian/Pacific Islander fourth-grade girls who took the test?

II. Qualitative Data (Post Intervention) from Piro, J., Dunlap, K. & Shutt. T. (2014). A collaborative Data Chat: Teaching summative assessment data use in pre-service teacher education. *Cogent Education, 1*(1), 1-24.

1. What is your level of comfort in understanding data sets after participating in the Data Chat? (Please list the ways you understand data. Please explain why you do/do not have comfort with understanding data sets.) Give examples of areas of growth.

2. What is your level of comfort in analyzing data sets after participating in the Data Chat? Compare your response to how you felt about these data behaviors before the Data Chat. Please give specific examples of your growth in this area.

3. What is your level of comfort in using data sets for instructional interventions after participating in the Data Chat? Compare your response to how you felt about these data behaviors before the Data Chat. Please give specific examples of your growth in this area.

Appendix D: NU Data Knowledge Scale

Credit:

Doll, B., Horn, C., & Shope, R. (2010). NU data: Using data to foster the school success of students with disabilities (pp. 1-25): Institute of Educational Sciences. https://ies.ed.gov/funding/grantsearch/details.asp?ID=1131

Sikorski, J. D. (2016). *Examination of the NU Data Knowledge Scale*. (Publication No. 10125684) [Doctoral dissertation, University of Nebraska]. ProQuest Dissertations & Theses Global.

NU Data Knowledge Scale

Name: _____ Date: _____

School: _____

For each scenario, please circle the best answer.

1. When is an intervention evidence based?
   a. When other people have used it and found that it worked well
   b. When the author says that the intervention shows meaningful change
   c. When someone has collected pre and post data that shows meaningful change
   d. When the intervention has a national sample

2. What is baseline data?
   a. Data that is collected over a short period of time
   b. Data that is collected after an intervention is implemented
   c. Data collected before an intervention has been implemented
   d. The bottom 25 percent of all data points

3. Which of the following is an example of a strong goal statement?
   a. The student's on-task behavior will increase by the end of the semester.
   b. The student's fluency will improve drastically over the semester as measured by AIMSweb data
   c. The student's grades will be a "B" or better by the end of the semester according to report cards
   d. The student will increase math computation scores by 15 points by the end of the semester as measured by DIBELS

4. Which of the following is an observable behavior?
   a. A student's attitude towards math or science class
   b. The number of times a student blurts out in class
   c. The intensity of a student's feelings about a poor grade
   d. The number of times a student becomes frustrated

5. How would you graph a student's behavior ratings of Rarely, Sometimes, Often, or Almost Always?
   a. By making each descriptor a different color
   b. By weighing each descriptor according to its positive or negative effects
   c. By assigning numbers to each descriptor
   d. By ranking each descriptor on a scale from negative to positive

6. Why is it important for students to be very self-confident about school work?
   a. So that they earn better scores on their State testing exams
   b. So that they are more motivated to continue to work on difficult tasks
   c. So that they feel better about their schooling
   d. So that they are more motivated to help their peers complete tasks

7. Which of the following is an example of good evidence of student's progress in math?
   a. Daily progress notes on student performance
   b. Self-monitoring data of the student's behavior **in** math class
   c. Notes from a conference call with the math teacher about a student's behavior
   d. Weekly quiz scores of the student's math class

NU Data Knowledge Scale

8. In addition to class grades, how could you reliably measure the academic performance of students in reading?
   a. By reviewing curriculum based measures benchmark scores
   b. By asking the students how they are doing
   c. By reviewing their academic grades from the last two year
   d. By giving the students a pop-quiz in one of their classes

9. What should you do before collecting information on a student?
   a. Collect baseline data on the student in his/her core classes
   b. Decide how you are going to graph the data that you collect
   c. Define and describe the identified problem
   d. Meet with the student to talk about the identified problem

10. What is an important consideration when choosing an intervention?
    a. How easily is the intervention implemented
    b. How will the data look once it is graphed
    c. How popular is the intervention package in my district
    d. How many students does the intervention affect

11. You have been monitoring the number of times a student left his seat during class. You graphed his progress on a line graph, and you want to show the parents that he is improving rapidly and very close to meeting his goal. How could the line graph show the parents that the student is close to reaching the goal?
    a. Show the parents a line graph that compares the number of times the student left his seat to thenumber of times a classmate left his seat
    b. Add a line to the graph that shows the decreasing trend in the student's out of seat behavior
    c. Add a line that separates the before intervention and during intervention data on the graph
    d. Collapse the data into weekly averages to show parents the decreasing average of the student beingout of his seat over time

12. Pat is constantly disrupting class by being out of his seat. If you wanted to measure how much Pat was out ofhis seat during a 15 minute observation, how would you record it?
    a. Setting a timer every time he left his seat and stopping it when he returns
    b. Putting a hash mark on a piece of paper every time he left his seat
    c. Rating the disruptiveness of his off task behavior on a scale from 1 to 10
    d. Counting the number of students who stopped working when he left his seat

13. Your team has collected data on a student with behavioral disorders for several weeks and is now ready to implement an intervention. How would you show where an intervention started on a line graph?
    a. Label where the intervention began on the data file worksheet
    b. Create a separate graph for the pre-intervention and post intervention data
    c. Draw a vertical line on the graph that separates the baseline data from the intervention data
    d. Draw a line that shows the trend across pre and post intervention data

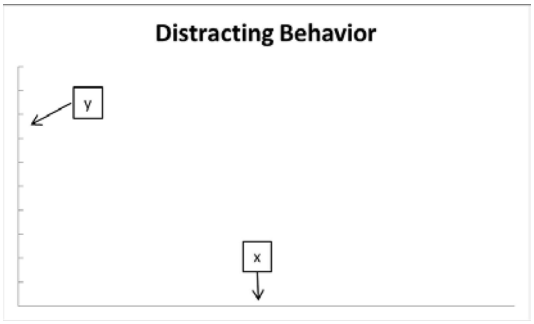
14. A teaching team is worried about a student who is not passing her English class. The team's data show that the student increased her work completion from 45% of assignments to 60% of assignments. Still, the studentwas failing because her grades on each assignment were still low. Given what the team knows, what would be their next step?
    a. Shorten the length of the student's assignments
    b. Place the student on a behavior plan
    c. Gather data on the student's attention to work
    d. Gather data on work completion and accuracy

NU Data Knowledge Scale

15. A third grade teacher surveyed the students to see which subject was their favorite: math, science, reading, or social studies. If the teacher wanted to show the student's a graph describing the percent of students preferring each subject, which graph should they choose?
    a. Stacked bar graph
    b. Line graph
    c. Scatter plot
    d. Pie Graph

16. A sixth grade teacher notices that her students appear to be arguing and complaining more than usual. She would like to collect data about what is taking place in her classroom. What kind of data collection would beuseful in collecting the information she wants to measure?
    a. Collect anonymous survey data on the students' perceptions of the classroom environment
    b. Tally the number of times students argued or complained in her classroom
    c. Give the students a survey asking which subjects are their favorite at school
    d. Consult fellow teachers for their thoughts and ideas on ways to improve the classroom climate

17. After collecting data on a student's distracting behavior **in** class, a teacher wants to graph the number of times the student engaged **in** distracting behavior over a two week period on the line graph below. What would you label the x and y axes in the below graph?

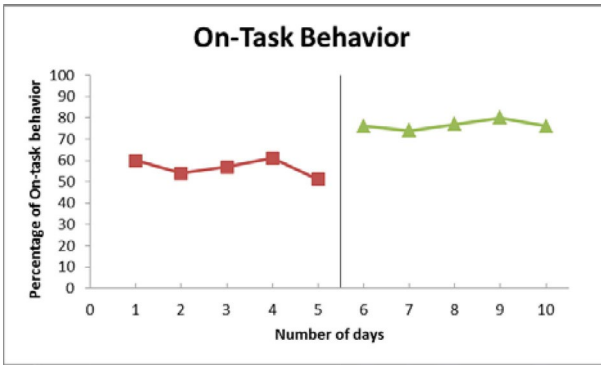


    a. The number of behaviors on the x-axis and the class periods on the y-axis
    b. The date on the x-axis and the number of distracting behaviors on the y-axis
    c. The weekly averages on the x-axis and the number of distracting behaviors on the y-axis
    d. The date on the x-axis and the number of times the student left his seat on the y-axis

18. A special education team met to make a plan for a student with a behavior problem. They defined the target behavior and created a rating scale from O to 4; with O representing a bad day and 4 representing a good day.They set a goal of the student earning a 3 or better each day. They collected data, but when they graphed it they were disappointed by how far the student was from meeting the goal they set. What step did the team forget in creating their plan?
    a. Collect data describing the student's initial behavior
    b. Define a goal related to the student's behavior
    c. Rate the student's behavior in multiple settings
    d. Record the student's behavior in a continuous manner

NU Data Knowledge Scale

19. How could you describe the difference in data between the before intervention and during interventionphases on the graph below?



a. It is impossible to tell because there was too much variability in each phase
b. The intervention was not effective because the student became less on-task after the intervention was implemented
c. The intervention was effective in increasing the student's on-task behavior because the data in the during phase do not overlap with data in the before phase
d. There are not enough data points to determine if the intervention had an effect

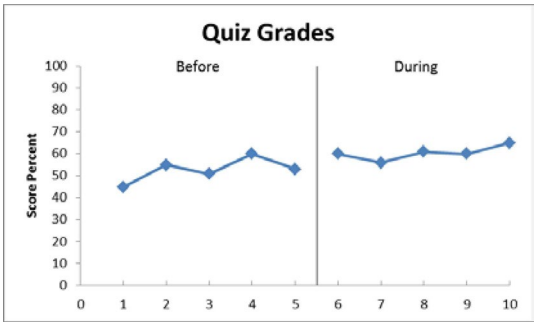
20. A student with cognitive disabilities is being taught the steps of washing her hands. She routinely skips one or two steps and becomes frustrated. To figure out which steps of hand washing the students was skipping, what should the teacher do next?
a. Write the hand washing steps in order and circle which ones she completes
b. Count every time the student leaves to wash her hands and record it at the end of the day
c. Put a tally mark on a piece of paper every time the student washes her hands correctly
d. Rate how well the student washed her hands on a scale from 1 to 10 and graph her daily percentages

21. Your team was referred a student who has a history of being extremely difficult and resistant with frequenttantrums. Your team is not sure why the problem behavior occurs. What should they do?
a. Implement an evidence based intervention program that reduces the tantruming behavior
b. Call an IEP meeting to determine whether to qualify the student for special education services
c. Observe the student at lunch and recess and tally the number of times the student tantrums
d. Use a broad screening measure to gather data on behaviors, academic skills, participation, andlearning for the student

22. You have been partnering with a first year teacher who has been struggling with classroom management. Theteacher chose a behavioral intervention that was appropriate for problem behaviors in the class. You coachedthe teacher through the intervention process and provided the materials needed to implement the intervention properly. After two weeks the teacher said they were stopping the intervention because it was not working. What should you do next?
a. Observe the teacher during a class to see if the intervention was implemented as it was written
b. Discontinue the intervention and try another evidence-based program
c. Refer the problem students for special educational services because they are resistant to intervention
d. Add additional behavioral interventions to the classroom to see if these improve classroom behavior

NU Data Knowledge Scale

23. A teacher has been implementing an academic intervention to increase a student's test scores. How should you describe the difference in data between the before intervention and during intervention phases on the graph below?



    a. The intervention was not effective in increasing the student's test scores because there was not a significant difference across phases
    b. The intervention was effective **in** increasing the student's quiz scores because the most data in the during phase do no overlap with data in the before phase
    c. The intervention was not effective because the student's test scores decreased after the intervention was implemented
    d. There are not enough data points **in** before and during phases to determine if the intervention had aneffect

24. You are preparing for a meeting with a principal to share data you collected on a student's on-task behavior. You collected 10 days' worth of data and graphed the data on a line graph in excel. When you look at the data,you are unable to make any meaningful decisions about the student's on-task behavior. What could you do to clarify changes in the student's on-task behavior over time?
    a. Draw a horizontal line on the graph at the level you hope the student will achieve
    b. Draw a vertical line on the graph that separates before and during intervention phases
    c. Draw a slanted line on the graph that reflects the pattern of the student's on-task behavior
    d. Change the graph type to bar graph

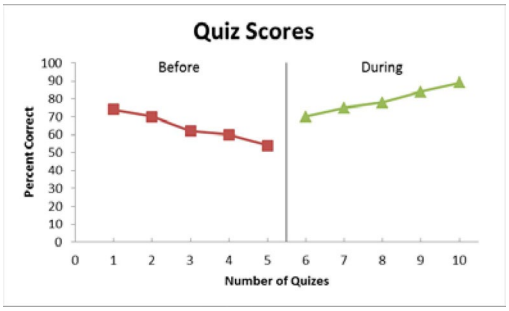
25. A team of four teachers met briefly to create a plan for collecting data on a student who was consistently disruptive during their classes. They all decided to record the number of times the student was off-task duringtheir class periods by tallying the number of times the student was disruptive. When they met after school, their tallies varied greatly and they could not agree on what the student's problem behavior was. What did they forget to do before collecting data on the student?
    a. Define the target behavior in precise terms
    b. Observe the student during recess
    c. Have frequent meetings about the student
    d. Decide how often they would tally the behaviors

26. You have been collecting data on a student for several weeks and decided to implement an intervention with the goal that your student would increase work completion from 45 percent to 80 percent of assignments. Your student has not missed completing an assignment for the last three weeks and appears to have reached this goal. What should you do next?
    a. Continue the intervention and data collection
    b. Discontinue collecting and recording the student's progress
    c. Implement an additional interventions that supports work completion
    d. Decrease the intervention and continue to monitor the student's work completion for two more weeks

NU Data Knowledge Scale

27. A middle school team has been implementing an evidence-based intervention for student bullying. They are concerned that the teasing program might not be appropriate because 90% of their school's enrollment is Latino/a and the program was written for a low-income, predominately white college town in Southern Mississippi. Parents requested the school use an evidence-based program, but a counselor urges the team to use a peacemaking program that was written by a former counselor in the district because it is a better matchto the students' culture. What should the team do?
    a. They should choose the evidenced based intervention because it has been empirically tested
    b. They should choose the peacemaking program because it was designed for the culture of the district
    c. They should drop the peacemaking program because it is not evidenced based
    d. They should adapt the evidence-based program to fit the culture of their students

28. How would you describe the trend test scores in the before and during phases of the graph below.



    a. The before trend is increasing and the during trend is decreasing
    b. Both the before and during trend are increasing
    c. The before trend is decreasing and the during trend is increasing
    d. The before trend is improving and the during trend is worsening

29. An Art teacher wanted to know how much class time a student was missing when throwing a tantrum. How should this be recorded?
    a. Putting a hash mark on a piece of paper every time the student threw a tantrum and record the daily total
    b. Starting a timer every time the student started to tantrum and stopping it when the student began working and recording the daily total
    c. Rating the disruptiveness of his tantrum on a scale from 1 to 10 and graphing the results
    d. Counting the number of students stopped working when the tantrum took place

30. A third grade student recently moved into the school district and has been attending your school for four weeks. The classroom teacher has referred this student to your student assistance team thinking that the student's inability to read at grade level may be due to a learning disability. How could your team gain the most useful information about this student's current abilities and ability to learn?
    a. Conduct time-sampling observations of the student during reading instruction
    b. Give the student a standardized achievement battery and cognitive abilities test
    c. Use curriculum based measures to track the student's progress in reading
    d. Collect information about the student's quarterly grades in all academic areas

Appendix E: LVD-Test (English)

Credit:

Zeuch, N., Forster, N., & Souvignier, E. (2017). Assessing teachers' competencies to read and interpret graphs from Learning Progress Assessment: Results from tests and interviews. *Learning Disabilities Research & Practice, (32)*1, 61-70. https://doi.org/10.1111/ldrp.12126

LVD-Test English

Please read the following information carefully:

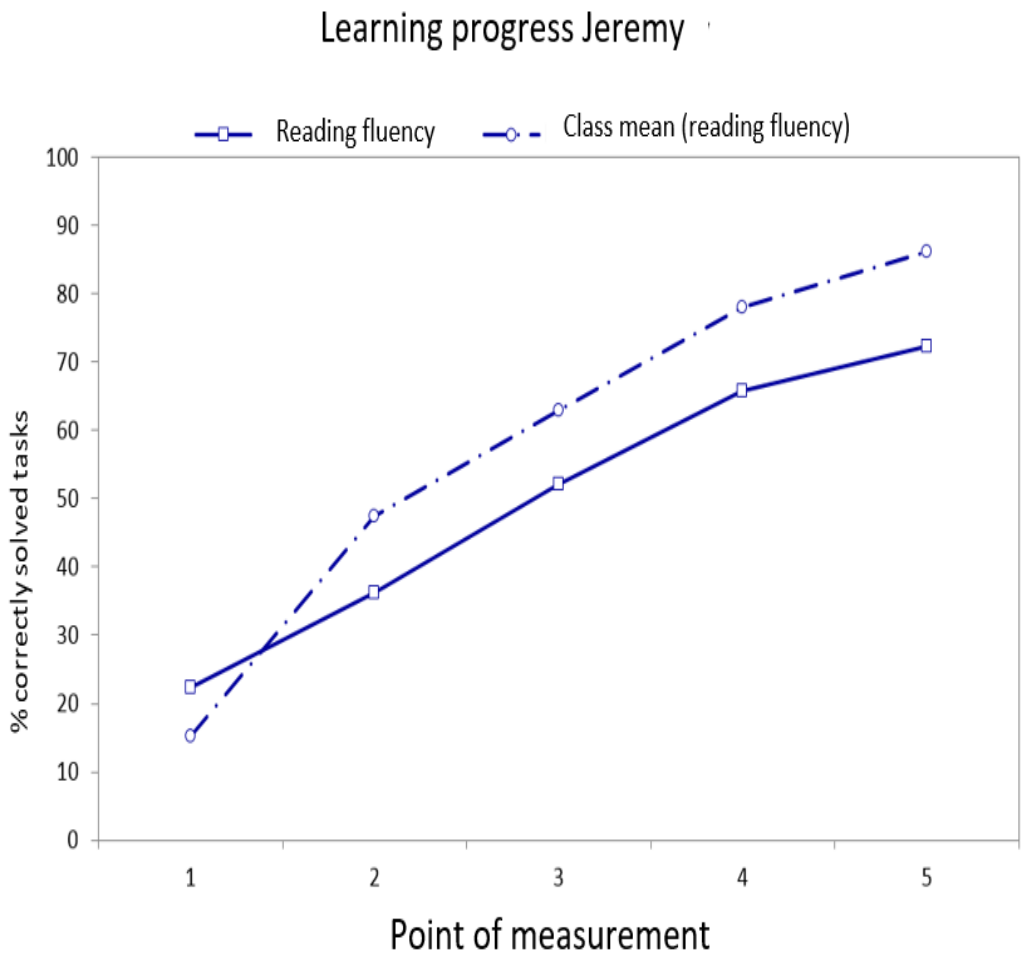
In the following, you will be presented a series of illustrations that represent the learning progress of different students. These students took five math or reading tests with a two-week-distance between each test. The illustrations depict the students' results.

Next to the illustrations, there will be different statements. Your task is to evaluate in how far the particular statements match the information represented in the illustrations.

For the subject of reading, reading fluency and reading comprehension have been tested. Please note that reading fluency is required to achieve reading comprehension, as students must be able to read a text carefully in order to obtain information from it.

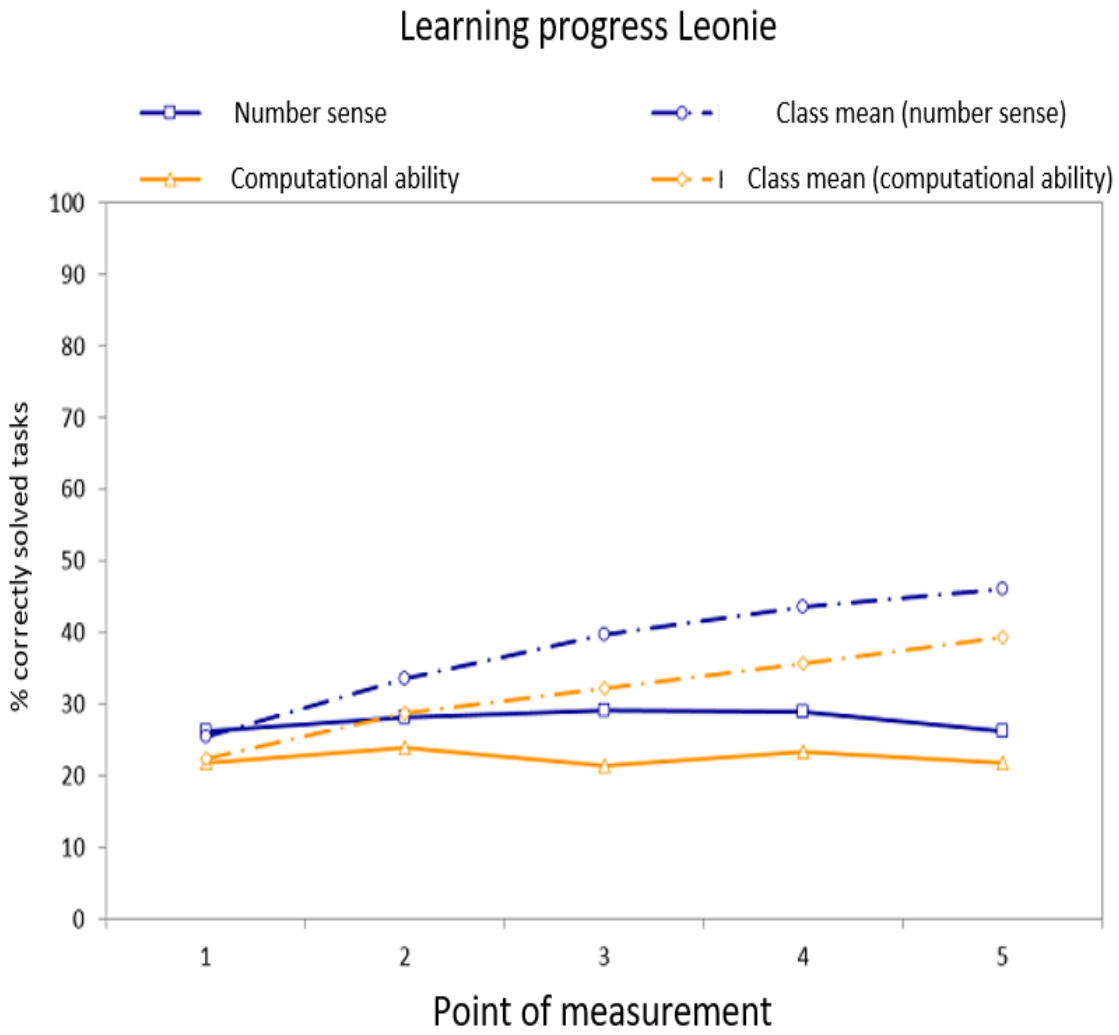
For the subject of math, understanding of numbers and numeracy skills have been tested. Please note that the understanding of numbers is required to achieve numeracy as students must be able to read and understand numbers in order to do calculations.

Task 1


Learning progress Jeremy
Reading fluency
Class mean (reading fluency)
% correctly solved tasks
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Point of measurement

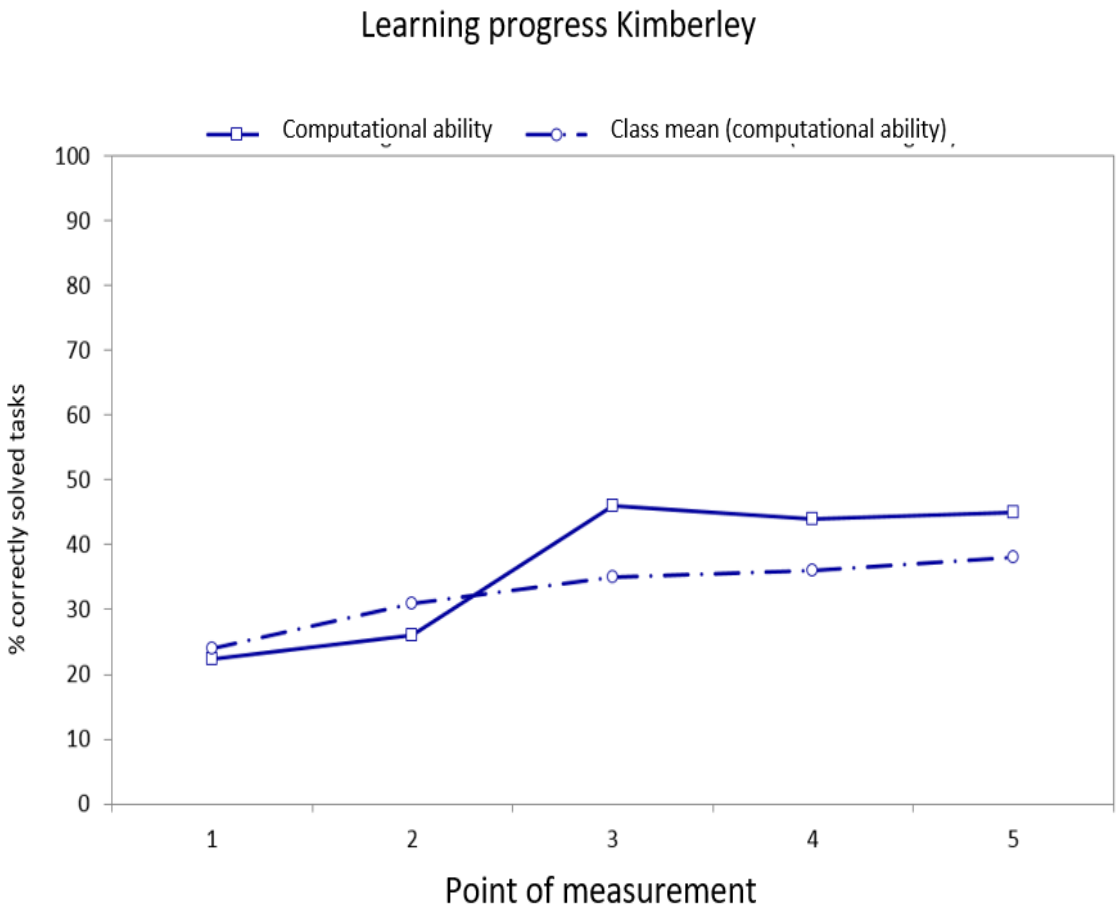
	Please evaluate in how far the following statements match the information available in the illustration above.	**1 very poor**	**2**	**3**	**4**	**5**	**6**	**7 very good**
a)	In comparison to the class, Jeremy starts off on a high performance level. He develops positively, but he shows less positive development in terms of performance than the class. On the last point of measurement, he is located on a low performance level as compared to the class.	○	○	○	○	○	○	○
b)	In comparison to the class, Jeremy starts off on a low performance level which stagnates at first. Subsequently, Jeremy shows a more positive development than the class and on the last point of measurement is located on a high performance level as compared to the class.	○	○	○	○	○	○	○
c)	In comparison to the class, Jeremy starts off on a high performance level. He shows no development in performance, while the class develops positively. On the last point of measurement, Jeremy is located on a lower performance level than the class.	○	○	○	○	○	○	○
d)	In comparison to the class, Jeremy starts off on a low performance level. He shows a strong positive development in performance that is higher than that of the class. On the last point of measurement, he is located on a high performance level.	○	○	○	○	○	○	○
e)	In comparison to the class, Jeremy starts off on a low performance level. He doesn't develop positively in performance, while the class does. On the last point of measurement the student is located on a low performance level as compared to the class.	○	○	○	○	○	○	○

Task 2


Learning progress Leonie
Number sense
Class mean (number sense)
Computational ability
Class mean (computational ability)
% correctly solved tasks
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Point of measurement

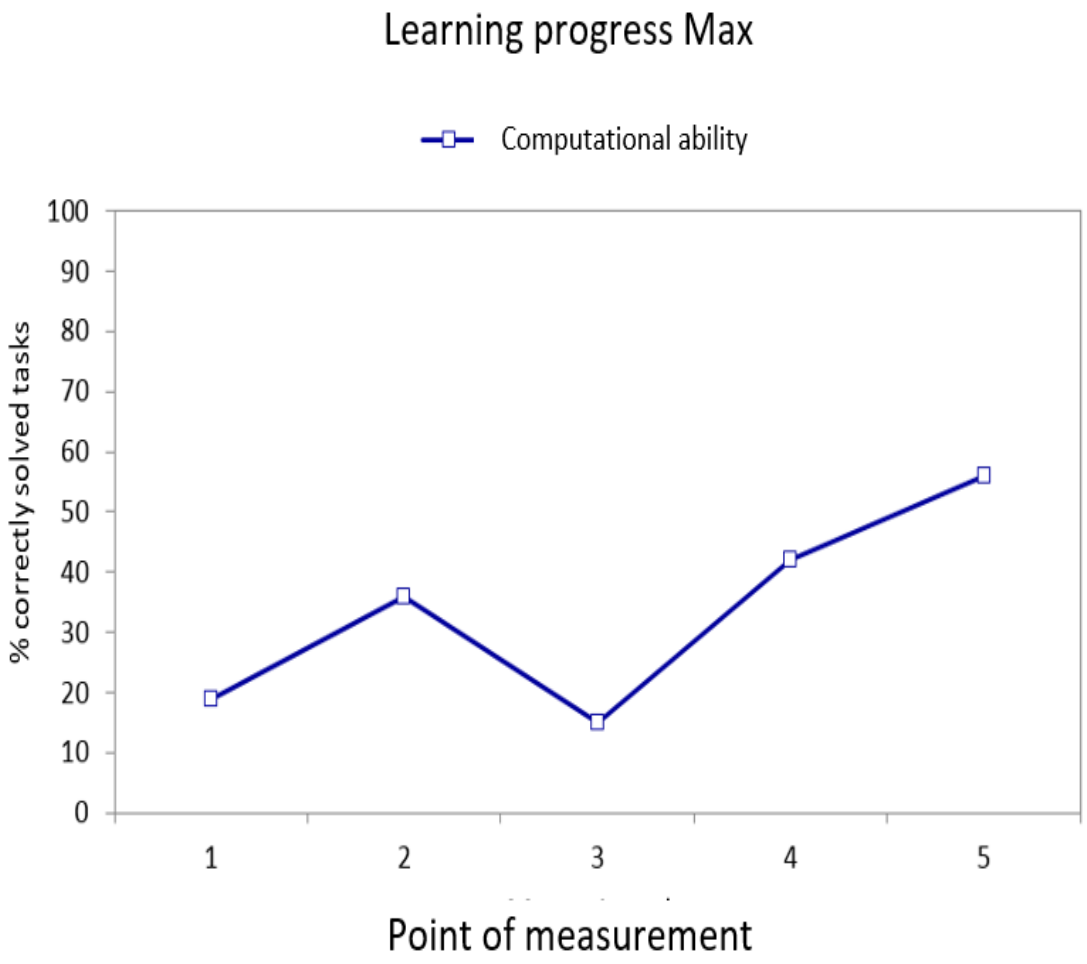
	Please evaluate in how far the following statements match the information available in the illustration above.	1 very poor	2	3	4	5	6	7 very good
a)	In comparison to the class, Leonie starts off on an average performance level in both areas. She doesn't show a development in performance and on the last point of measurement is still located on an average performance level as compared to the class. Leonie should primarily be promoted in terms of the understanding of numbers.	○	○	○	○	○	○	○
b)	In comparison to the class, Leonie starts off on an average performance level in both areas. She doesn't show a development in performance and on the last point of measurement is located on a low performance level as compared to the class. Leonie should primarily be promoted in terms of the understanding of numbers.	○	○	○	○	○	○	○
c)	In comparison to the class, Leonie starts off on an average performance level in both areas. She develops negatively and on the last point of measurement is located on a low performance level as compared to the class. Leonie should be primarily promoted in terms of numeracy skills.	○	○	○	○	○	○	○
d)	In comparison to the class, Leonie starts off on a low performance level in both areas. She develops positively and on the last point of measurement is located on a higher performance level than the class. Leonie thus doesn't need to be particularly promoted in any way.	○	○	○	○	○	○	○
e)	In comparison to the class, Leonie starts off on an average performance level in both areas. She shows a positive development in performance and on the last point of measurement is located on an average performance level as compared to the class. Leonie doesn't need to be particularly promoted in any way.	○	○	○	○	○	○	○

Task 3


Learning progress Kimberley
Computational ability
Class mean (computational ability)
% correctly solved tasks
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Point of measurement

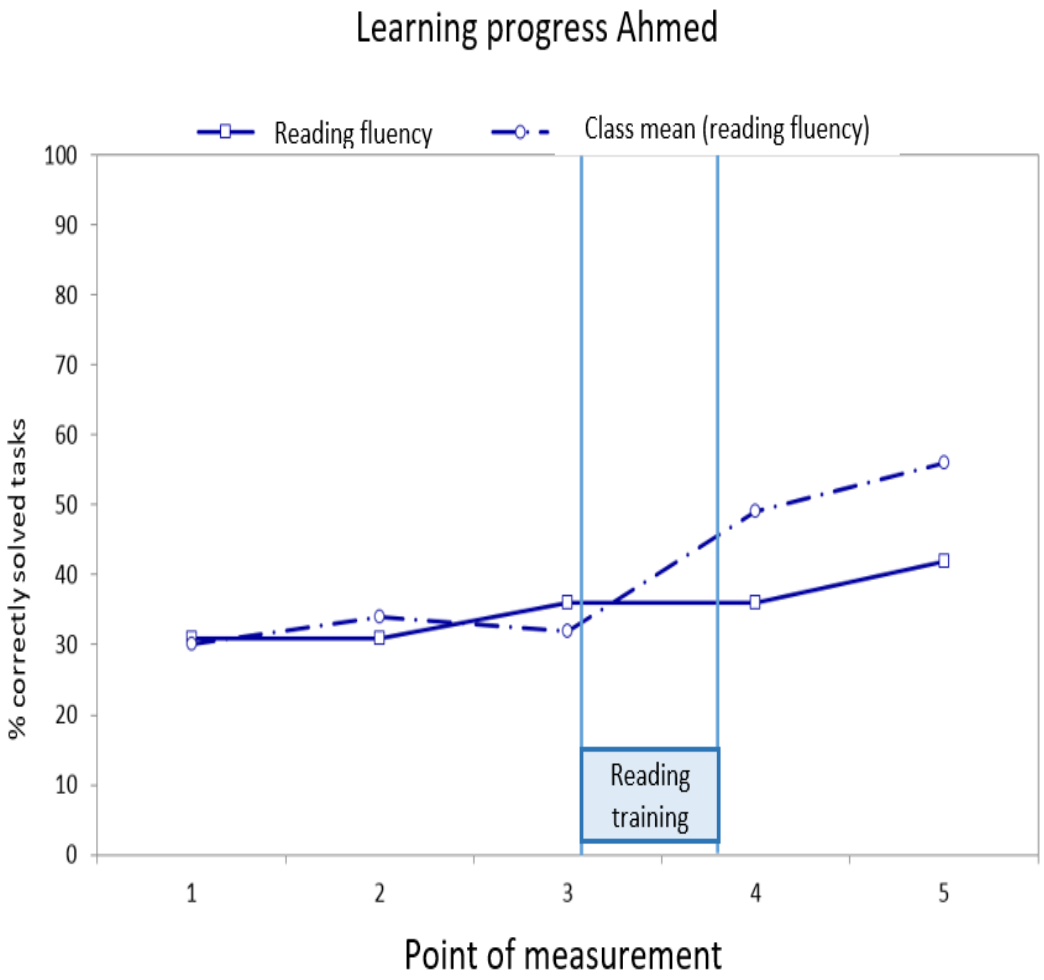
	Please evaluate in how far the following statements match the information available in the illustration above.	1 very poor	2	3	4	5	6	7 very good
a)	Compared to the class, Kimberley starts off on a low performance level. Her performance stagnates, while the class develops more positively. Hence, on the last point of measurement, Kimberley is located on a low performance level as compared to the class.	○	○	○	○	○	○	○
b)	Compared to the class, Kimberley starts off on a low performance level. Subsequently, she shows a more positive development in performance, which is stronger than that of the class. Therefore, on the last point of measurement, Kimberly is located on a high performance level as compared to the class.	○	○	○	○	○	○	○
c)	Compared to the class, Kimberley starts off on a high performance level. She develops positively, yet less positively than the class. Kimberley is thus on the last point of measurement located on a lower performance level than the class.	○	○	○	○	○	○	○
d)	Compared to the class, Kimberley starts off on an average performance level. She shows a stronger development in performance than the class, so that on the last point of measurement, she is located on a high performance level as compared to the class.	○	○	○	○	○	○	○
e)	Compared to the class, Kimberley starts off on an average performance level. She develops positively, yet less positively than the class. That is why on the last point of measurement, she is located on a low performance level as compared to the class.	○	○	○	○	○	○	○

Task 4


Learning progress Max
Computational ability
% correctly solved tasks
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Point of measurement

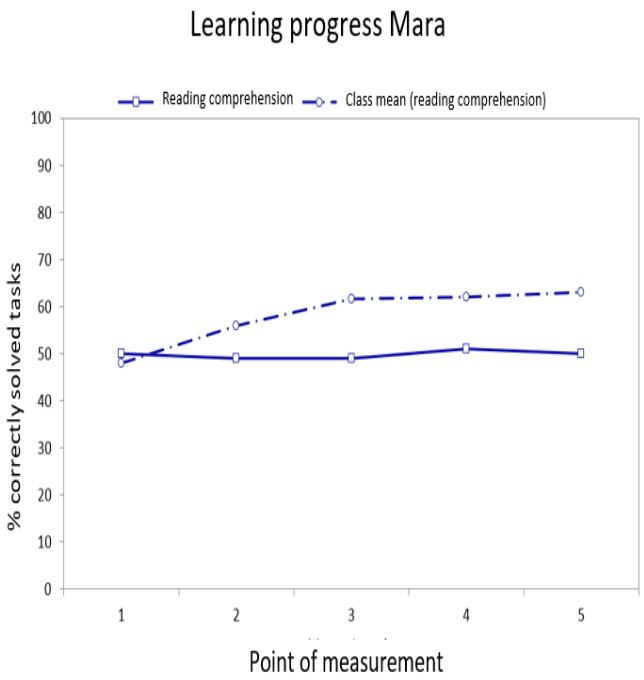
	Please evaluate in how far the following statements match the information available in the illustration above.	**1 very poor**	**2**	**3**	**4**	**5**	**6**	**7 very good**
a)	Already at the beginning, Max solves the majority of the tasks correctly. He shows a negative development in performance and deteriorates on every point of measurement. Max urgently needs promotion.	○	○	○	○	○	○	○
b)	At the beginning of the measurement, Max solves less than one out of four tasks correctly. He develops positively at first, but shows a decline in performance on the third point of measurement. Max urgently needs promotion.	○	○	○	○	○	○	○
c)	On the first test, Max solves less than one out of four tasks correctly. He shows a volatile development in performance until the third point of measurement, in total his development in performance is however positive. Max thus doesn't need urgent promotion.	○	○	○	○	○	○	○
d)	At the beginning of the measurement, Max solves less than one out of four tasks correctly. He shows a huge variation in performance in every period of measurement and doesn't develop positively. Max urgently needs promotion.	○	○	○	○	○	○	○
e)	Already at the beginning, Max solves the majority of tasks correctly. He develops positively and improves on every point of measurement. Max doesn't need urgent promotion.	○	○	○	○	○	○	○

Task 5


Learning progress Ahmed
Reading fluency
Class mean (reading fluency)
% correctly solved tasks
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Reading training
Point of measurement

	Please evaluate in how far the following statements match the information available in the illustration above.	1 very poor	2	3	4	5	6	7 very good
a)	Compared to the class, Ahmed starts off on a low performance level. He is unable to profit from the reading exercises and isn't developing as positively as the class. On the last point of measurement, Ahmed is located on a low performance level as compared to the class.	○	○	○	○	○	○	○
b)	Compared to the class, Ahmed starts off on an average performance level. Unlike the class, he is able to profit from the reading exercises and shows a more positive development in performance than the class. On the last point of measurement, Ahmed is thus located on a higher performance level than the class.	○	○	○	○	○	○	○
c)	Compared to the class, Ahmed starts off on a low performance level. He is able to profit from the reading exercises, but doesn't develop as positively as the class. Hence, on the last point of measurement, he is located on a low performance level as compared to the class.	○	○	○	○	○	○	○
d)	Compared to the class, Ahmed starts off on a low performance level. He is able to profit from the reading exercises and develops more positively than the class. Hence, on the last point of measurement, he is located on a higher performance level than the class.	○	○	○	○	○	○	○
e)	Compared to the class, Ahmed starts off on an average performance level. While the class's performance develops more positively after the reading exercises, he is unable to profit from the reading exercises. On the last point of measurement, Ahmed is located on a low performance level as compared to the class.	○	○	○	○	○	○	○

Task 6


Learning progress Mara
Reading comprehension
Class mean (reading comprehension)
% correctly solved tasks
Point of measurement

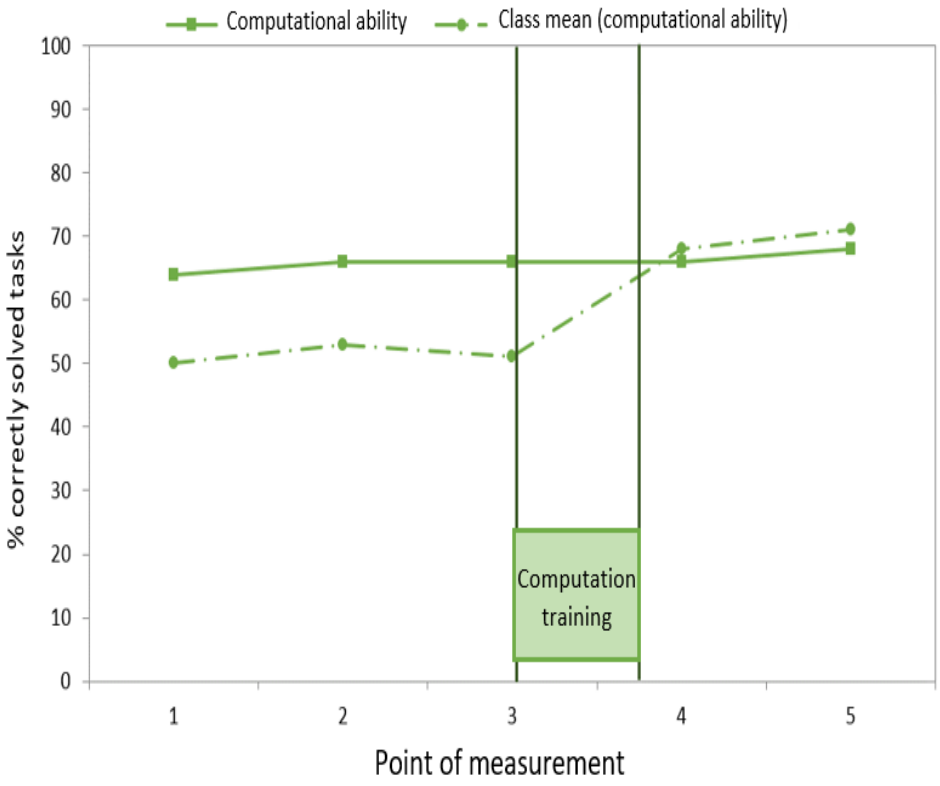

Mara's class compared to all classes
Class mean (reading comprehension)
Lower normal level
Upper normal level
% correctly solved tasks
Point of measurement

	Please evaluate in how far the following statements match the information available in the illustration above.	**1 very poor**	**2**	**3**	**4**	**5**	**6**	**7 very good**
a)	Compared to the class, Mara starts off on an average performance level. She shows no development over the course of time and on the last point of measurement is located on a low performance level as compared to the class. In the light of the whole class being highly-performing, Mara doesn't need particular promotion, though.	○	○	○	○	○	○	○
b)	Compared to the class, Mara starts off on a high performance level. She shows a negative development in performance and on the last point of measurement is located on a low performance level as compared to the class. As Mara's performance is below-average, also in the grand comparison to all classes, she urgently needs promotion.	○	○	○	○	○	○	○
c)	Compared to the class, Mara starts off on an average performance level. She shows no development in performance and on the last point of measurement is located on a low performance level as compared to the class. In the light of the whole class not being particularly high-performing, Mara urgently needs promotion.	○	○	○	○	○	○	○

d)	Compared to the class, Mara starts off on an average performance level. She then shows a positive development and on the last point of measurement is located on a high performance level as compared to the class. For the whole class being rather high-performing, Mara doesn't need to be urgently promoted.	○	○	○	○	○	○	○
e)	Compared to the class, Mara starts off on a high performance level. Over the course of time, she shows a decline in performance and on the last point of measurement is located on an average performance level as compared to the class. In the light of the whole class not being particularly high-performing, Mara urgently needs promotion.	○	○	○	○	○	○	○

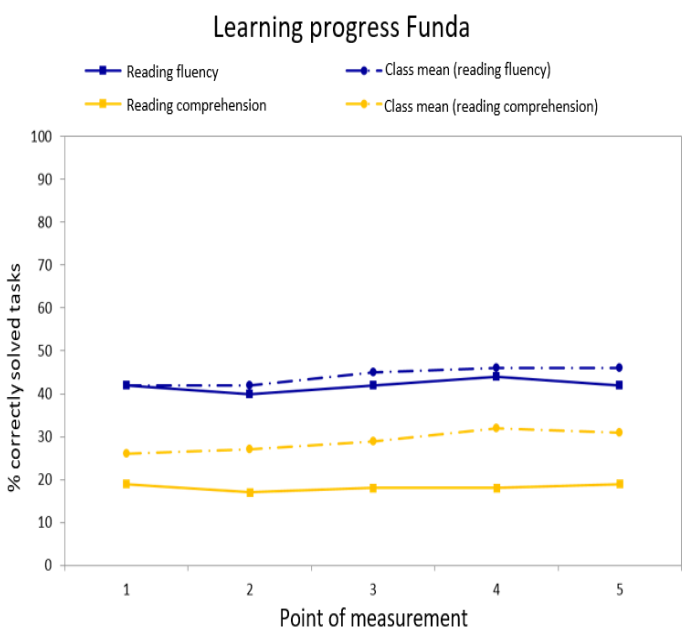
Task 7

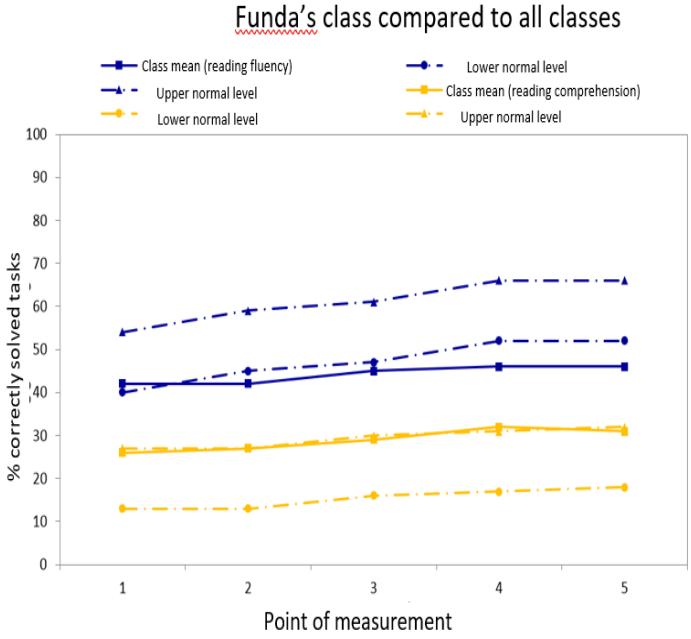
Learning progress Jacob



	Please evaluate in how far the following statements match the information available in the illustration above.	**1 very poor**	**2**	**3**	**4**	**5**	**6**	**7 very good**
a)	Compared to the class, Jacob starts off on a high performance level. Unlike the class, he is unable to profit from the computational exercises so that on the last point of measurement, he is located on a low performance level as compared to the class. Jacob therefore should repeat the computational exercises.	○	○	○	○	○	○	○
b)	Compared to the class, Jacob starts off on a high performance level. Unlike the class, he is unable to profit from the computational exercises. On the last point of measurement, Jacob is located on an average performance level as compared to the class. It therefore makes no sense for Jacob to continue the computational exercises.	○	○	○	○	○	○	○
c)	Compared to the class, Jacob starts off on a low performance level. He is able to profit from the computational exercises so that on the last point of measurement he is located on a high level of performance as compared to the class. It therefore isn't necessary for Jacob to repeat the computational exercises.	○	○	○	○	○	○	○
d)	Compared to the class, Jacob starts off on an average performance level. He is unable to profit from the computational exercises so that on the last point of measurement, he still is located on an average performance level as compared to the class. Jacob therefore needs an intervention other than the computational exercises.	○	○	○	○	○	○	○
e)	Compared to the class, Jacob starts off on a low performance level. He is able to profit from the computational exercises and on the last point of measurement is located on a high performance level as compared to the class. It therefore makes sense for Jacob to continue the successful computational exercises.	○	○	○	○	○	○	○

Task 8


Learning progress Funda
Reading fluency
Class mean (reading fluency)
Reading comprehension
Class mean (reading comprehension)
% correctly solved tasks
Point of measurement


Funda's class compared to all classes
Class mean (reading fluency)
Lower normal level
Upper normal level
Class mean (reading comprehension)
Lower normal level
Upper normal level
% correctly solved tasks
Point of measurement

	Please evaluate in how far the following statements match the information available in the illustration above.	1 very poor	2	3	4	5	6	7 very good
a)	Funda shows a positive development in performance. Regarding both reading fluency and reading comprehension, she shows a below-average performance as compared to the class. Funda should mainly be promoted regarding reading comprehension, as the class performs below-average in this area as compared to all other classes.	○	○	○	○	○	○	○
b)	Funda shows a stagnating development in performance. Regarding reading fluency, she performs below-average and regarding reading comprehension, she performs on average as compared to the class. She therefore should be primarily promoted regarding reading fluency, especially as the whole class isn't particularly high-performing in this area.	○	○	○	○	○	○	○
c)	Funda doesn't develop over the course of time. While she performs on average in the area of reading fluency, she only performs below-average in the area of reading comprehension as compared to class. Funda should primarily be promoted regarding reading fluency, as her whole class isn't particularly high-performing in this area.	○	○	○	○	○	○	○
d)	Funda shows a negative development. Regarding reading fluency, she scores better results than the class and in the area of reading comprehension, she scores average results as compared to the class. Funda should be primarily promoted regarding reading comprehension, as she solved fewer tasks correctly in this area.	○	○	○	○	○	○	○
e)	Funda shows a stagnating development in performance in both areas. Regarding reading fluency, Funda scores average results as compared to the class. Regarding reading comprehension, she scores below-average results as compared to the class. Funda should thus primarily be promoted regarding reading comprehension.	○	○	○	○	○	○	○

Appendix F: Graph Literacy Survey

Credit:

Oslund, E.L., Elleman, A.M., & Wallace, P.K. (accepted for publication). Factors related to data-based decision making: Examining experience, professional development, and the mediating effect of confidence on teacher graph literacy. *Journal of Learning Disabilities.*

Wallace, P. K. (2019). *Teachers' knowledge and implementation of response to intervention practices: Graph literacy and data-based decision making*. (Publication No. 13857437) [Doctoral dissertation, Middle Tennessee State University]. ProQuest Dissertations & Theses Global.

For the purpose of this survey, RTI includes Multi-tiered System of Supports (MTSS). We recognize some programs have more than 3 Tiers, so for the purpose of this survey, we define Tiers in the following way: Tier 1 = general education; Tier 2 = interventions that can include small group instruction, alternative, and/or additional interventions and; Tier 3 = intensive individual instruction and/or Special Education placement.

Also, you can save your responses at any time and return to finish the survey at a later time as long as it is within 6 days.

Q1 Grade level you currently teach (select all that apply)

- Elementary school (K-5)
- Middle school (6-8)
- High school (9-12)
- Other (please specify)

Q2 Are you currently a teacher or administrator in a K-12 school setting?

- Yes
- No

Q3 Are you familiar with Response to Intervention (RTI) [also known as Multi-tiered System of Supports (MTSS)]?

- Yes
- No

Q11 There are adequate professional development opportunities to strengthen Tier 2 intervention instruction.

Strongly Agree

Agree

Disagree

Strongly Disagree

I do not receive any training in Tier 2 instruction

Q12 The professional development opportunities in Tier 2 instruction are high quality.

Strongly Agree

Agree

Disagree

Strongly Disagree

I do not receive any training in Tier 2 instruction

Q14 There are adequate professional development opportunities to strengthen Tier 3 intervention instruction.

Strongly Agree

Agree

Disagree

Strongly Disagree

I do not receive any training in Tier 3 instruction

Q15 The professional development opportunities in Tier 3 instruction are high quality.

Strongly Agree

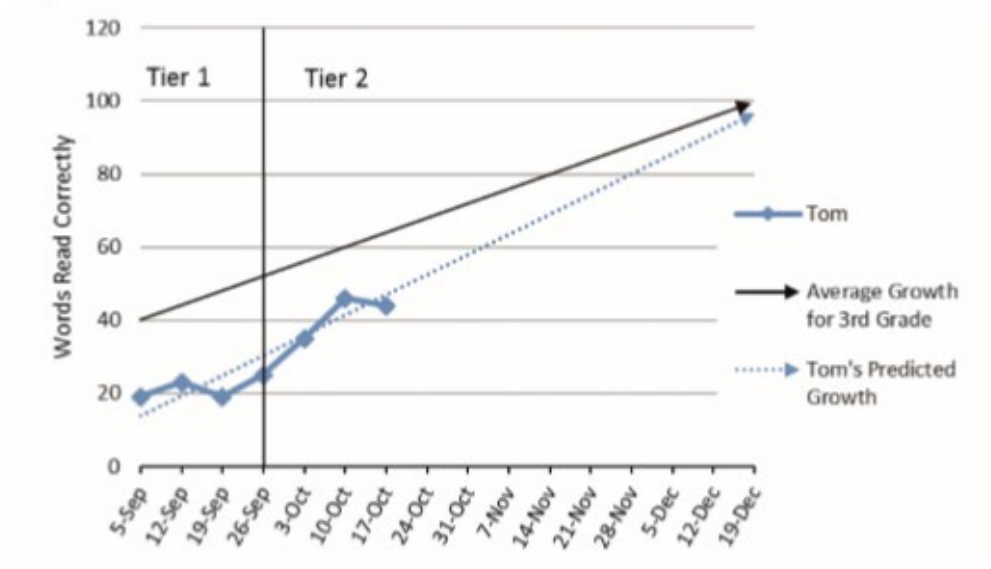
Agree

Disagree

Strongly Disagree

I do not receive any training in Tier 3 instruction

Graph 1



Q46 Tom was placed in Tier 2 intervention (as shown by the vertical line) on September 26th. This graph represents the data collected September 5th through October 17th. According to the graph, Tom is:

- Not adequately responding to Tier 2 instruction and should be placed in Tier 3
- Not adequately responding to Tier 2 instruction and should be left there
- Adequately responding to Tier 2 instruction and should be left there
- Tom should be moved back to Tier 1

Q47 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer

Q48 Tom:

- Read roughly half as many words as the average student at the start of the year and grew slower than average
- Read roughly half as many words as the average student at the start of the year and grew faster than average
- Read roughly the same number of words as the average student at the start of the year and grew slower than average
- Read roughly the same number of words as the average student at the start of the year and grew faster than average
- Read roughly twice as many words as the average student at the start of the year and grew slower than average
- Read roughly twice as many words as the average student at the start of the year and grew faster than average

Q49 Please briefly explain the reason for your answer choice.

_____

Q50 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer	

Q51 Based on the current data, by May or June; Tom will likely be _____ on Words Read per Minute.

- Below average
- Average
- Above average

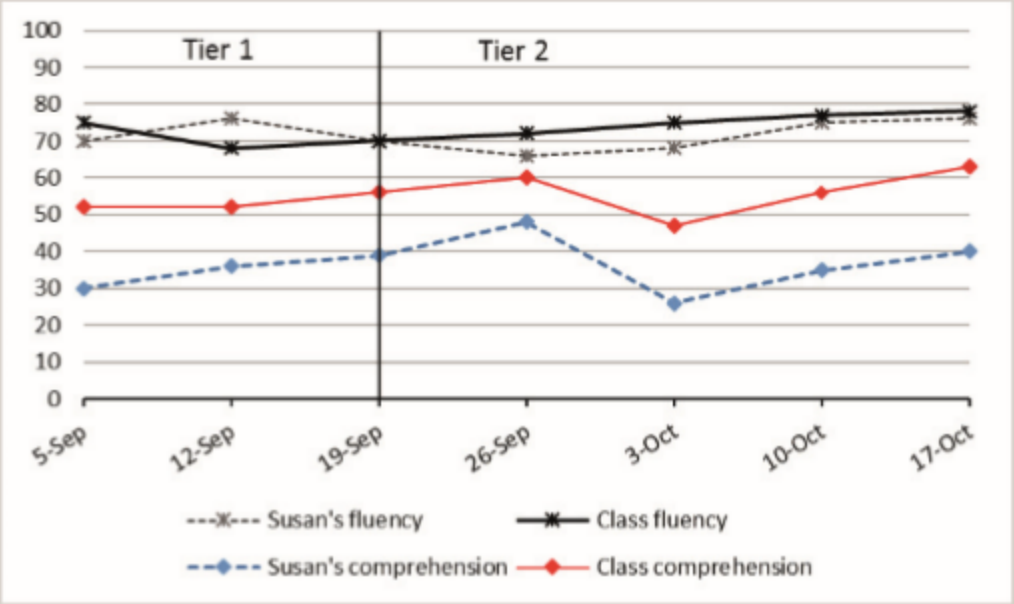
Q52 Please briefly explain the reason for your answer choice. _____

Q53 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer	

Graph 2



Q54 Susan was placed in a Tier 2 intervention (as shown by the vertical line) on September 19th for Reading Comprehension. According to her Comprehension scores:

- Susan was making adequate progress in Tier 1 and should be moved back to Tier 1 only
- Susan is making adequate progress in Tier 2 and should remain there
- Susan is not making adequate progress in Tier 2 and should be placed in a Tier 3 intervention
- Susan should be placed in an intervention for fluency only instead of comprehension
- Susan should be placed in an intervention for fluency in addition to comprehension

Q55 Please briefly explain the reason for your answer choice.

_____

Q56 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer ()

Q57 According to her Fluency scores:

Susan is making adequate progress in Tier 1 and should remain there

Susan is not making adequate progress and should be moved to a Tier 2 fluency intervention

Susan is not making adequate progress and should be moved to a Tier 3 fluency intervention

Susan should be placed in an intervention for fluency in addition to reading comprehension

Q58 Please briefly explain the reason for your answer choice.

_____

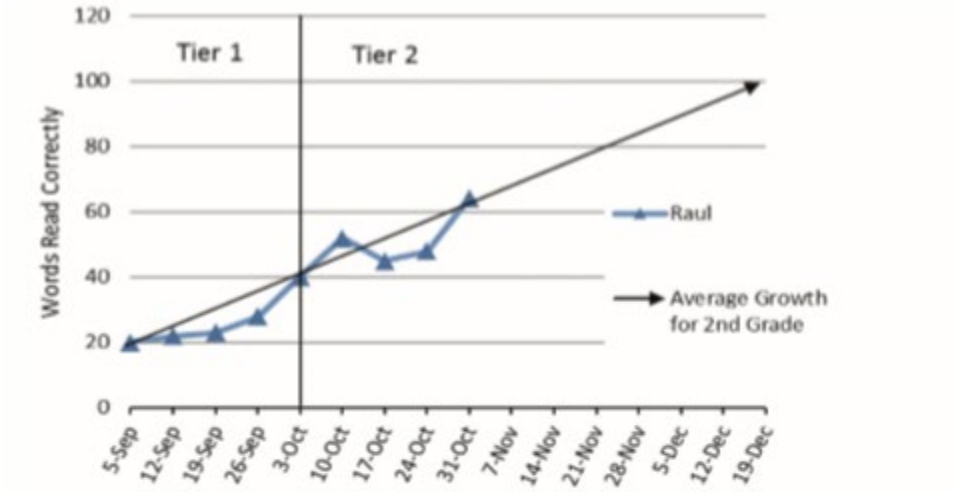
Q59 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer

Please select the best answer from the 9 available options.

Graph 3



Q60 Based on this graph, please indicate what you would recommend for Raul:

- Place in Tier 1 only
- Continue in Tier 1 only
- Place in Tier 2
- Continue in Tier 2
- Modify Tier 2
- Place in Tier 3
- Continue in Tier 3
- Modify Tier 3
- Refer for Special Education

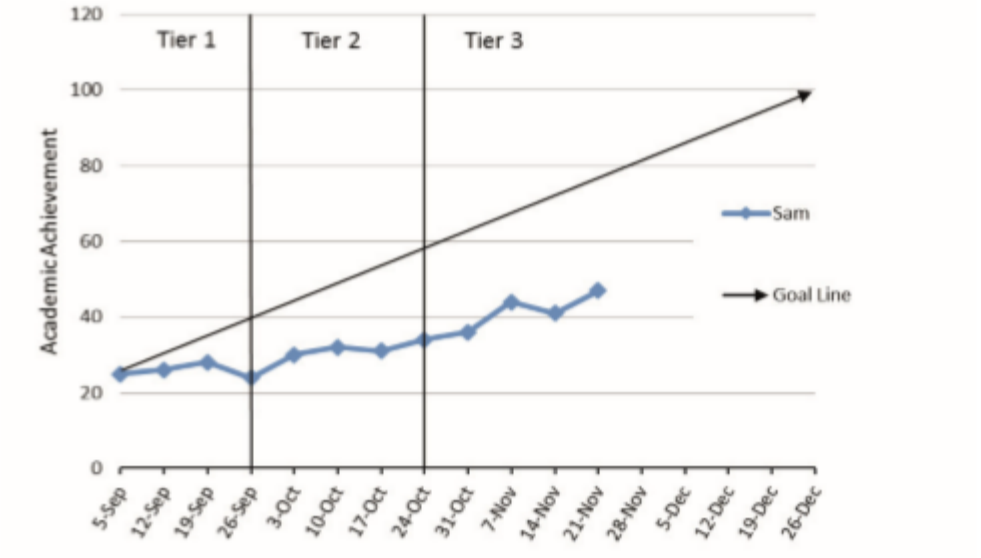
Q61 Please briefly explain the reason for your answer choice.

Q62 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer

Graph 4



Q63 Based on the graph, please indicate what you recommend for Sam:

- Place in Tier 1 only
- Continue in Tier 1 only
- Place in Tier 2
- Continue in Tier 2
- Modify Tier 2
- Place in Tier 3
- Continue in Tier 3
- Modify Tier 3
- Refer for Special Education

Q64 Please briefly explain the reason for your answer choice.

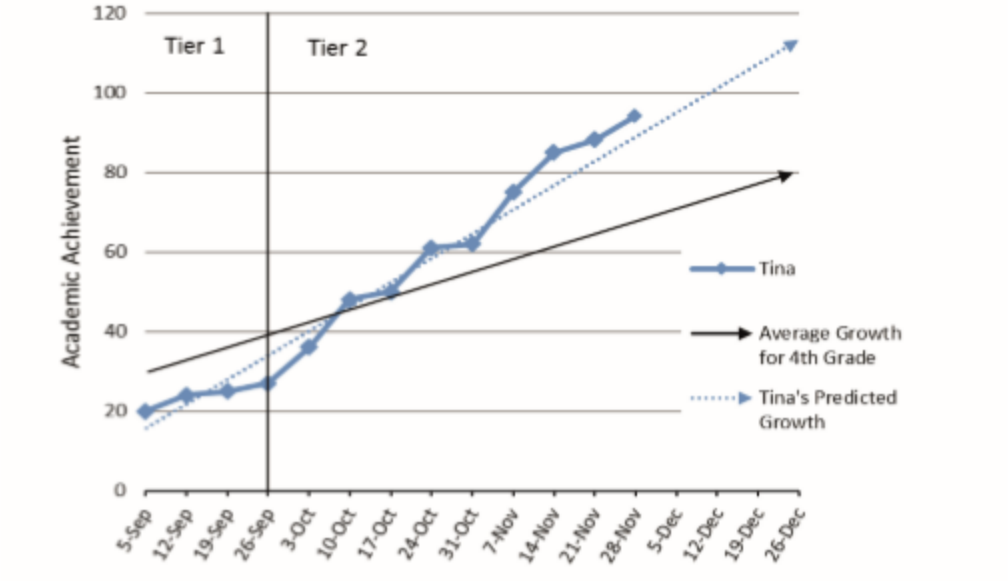
_____

Q65 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer	

Graph 5



Q66 Based on this graph, please indicate what you recommend for Tina:

- Place in Tier 1 only
- Continue in Tier 1 only
- Place in Tier 2
- Continue in Tier 2
- Modify Tier 2
- Place in Tier 3
- Continue in Tier 3
- Modify Tier 3
- Refer for Special Education

Q67 Please briefly explain the reason for your answer choice.

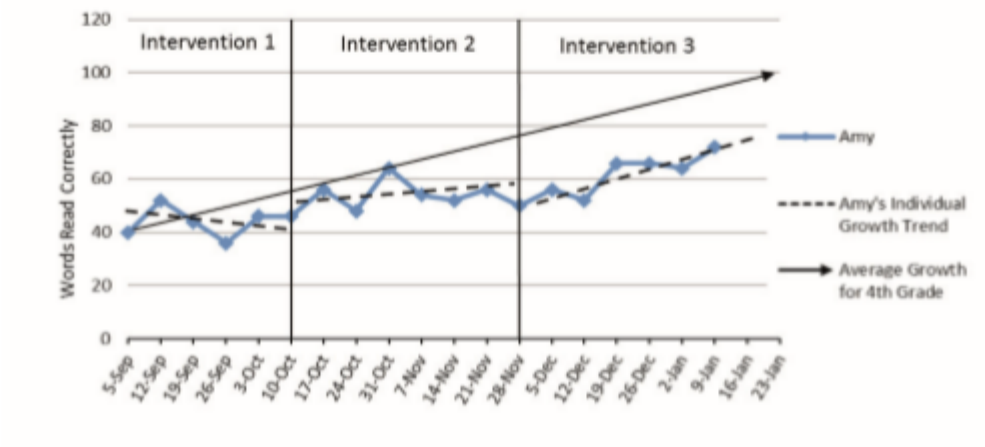
_____

Q68 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer	

Graph 6



Q69 Based on the graph, which intervention did Amy respond to the best?

Intervention 1

Intervention 2

Intervention 3

Cannot be determined from the graph

Q70 Please briefly explain the reason for your answer choice.

_____

Q71 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer

Q72 Amy is now in intervention 3. Based on her response, she will likely:

Grow at a faster rate than her peers and catch them by the end of the year

Grow at a slower rate than her peers and fall further behind by the end of the year

Grow at the same rate as her peers and stay equally behind for the rest of the year

Q73 Please briefly explain the reason for your answer choice.

_____

Q74 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer 

Q75 Based on the graph, please indicate what you recommend for Amy:

Intervention 1

Intervention 2

Intervention 3

Place her in new, more intensive intervention

Q76 Please briefly explain the reason for your answer choice.

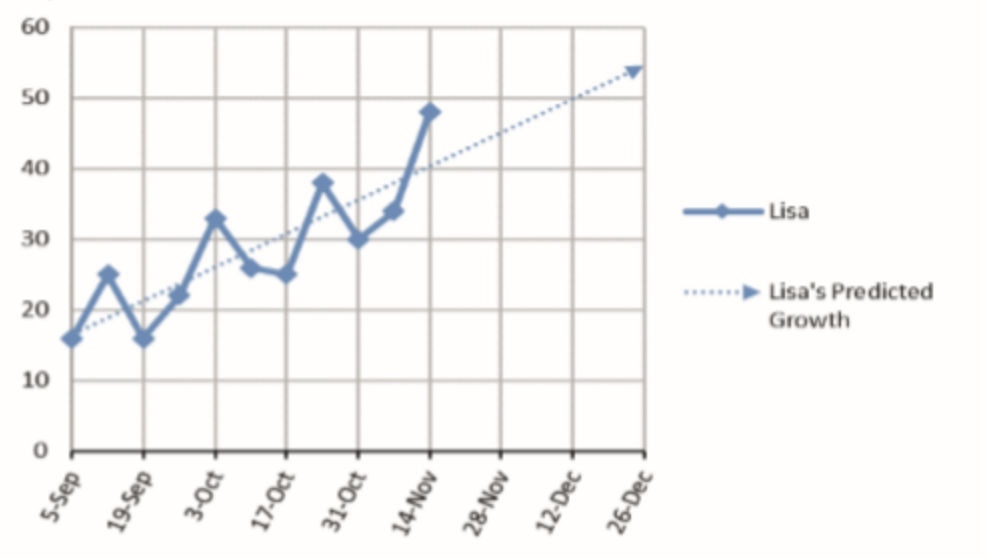
_____

Q77 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer 

Graph 7



Q78 What is Lisa's predicted growth score for December 12th?

- 43
- 62
- 50
- 55
- 40

Q79 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer

Q80 Lisa has a lot of bounce (i.e., fluctuation) in her data. Which of the following is the ***least likely*** contributing factor?

- The fidelity of assessment administration and scoring
- Lisa's motivation
- Variability in the difficulty level of the progress monitoring probes
- Too many progress monitoring probes being administered
- Lisa's mastery level of the skill being measured

Q81 Please briefly explain the reason for your answer choice.

_____

Q82 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer 

Q83 Ideally, what would be the ***best*** way to minimize the bounce/fluctuation in Lisa's data in order to get the most accurate estimate of her growth?

Administer fewer probes overall

Administer more probes at each measurement occasion and take the average score

Change the setting, time, and person administering the measure

There is no way to help reduce bounce/fluctuation

Q84 Please briefly explain the reason for your answer choice.

_____

Q85 How confident are you of your answer (0 being not at all confident and 100 being completely confident)?

0 10 20 30 40 50 60 70 80 90 100

Slide to answer 

Q86 Number of years teaching

▼ 1 (1) ... 21 or more (21)

Q87 My school is considered

Rural

Urban

Suburban

Q88 To the best of your knowledge, what percentage of students at your school receive free or reduced-priced lunches?

75.1% or more

50.1-75.0%

25.1-50.0%

25.0% or less

I don't know

Q89 Would you consider your school:

Low socio-economic status (SES)

Average SES

High SES

Q90 Please select the number of students enrolled at your school:

Up to 450 students

Between 451 and 700 students

More than 701 students

Q91 I am currently teaching (select all that apply)

General core-content education (e.g., reading, math, science)

Special Education

Special area (e.g., music, physical education, art, etc.)

I am an administrator

Other (please specify) _____

Q89 Please indicate your gender

Male

Female

Decline to state

Q90 In which state do you currently reside?

▼ Alabama (1) ... Wyoming (52)

Q91 Please indicate your race/ethnicity

African American

Asian/Pacific Islander

Hispanic

Native American or Alaskan Native

White

Multi-racial

Decline to answer

Q92 What is the highest level of formal education you have attained?

Bachelor's degree

Master's degree

Educational Specialist (Ed.S.)

Doctorate or other terminal degree

Other (please specify) _____