



## Thinking with Data: A Cross-Curricular Approach to Data Literacy

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### Overview

**Thinking with Data (TWD)** is an **Instructional Materials Design (IMD)** project which developed and tested a cross-curricular unit designed to cultivate middle school students' deep understanding of data literacy. The TWD unit consists of four, 2-week replacement modules for interdisciplinary implementation in 7th grade Social Studies, Mathematics, Science, and English Language Arts. The modules address issues of data representation, proportional reasoning, and data-based argumentation using real data in discipline-specific, problem-solving contexts aligned with relevant subject area standards.

**The context for the TWD modules is world water issues.** Activities and materials are designed around student investigations of water issues in the Tigris/Euphrates basin and in six US watersheds using real world data. Data manipulation across the unit centers on the notion of **proportional reasoning**, an important part of middle school curricula and the foundation for higher mathematics. In **Social Studies**, students use existing data to explore water availability and usage in Turkey, Syria, and Iraq, and try to devise fair ways of sharing available water. In **Mathematics**, they learn techniques of proportional reasoning to expand on their Social Studies work and develop data-based solutions and arguments for fair use. In **Science**, they learn about the science behind water issues in the Tigris/ Euphrates basin, beginning with how the water cycle manifests itself in the region, and how that and ditch irrigation contributes to soil salinity. Students then explore water issues in six US watersheds. In **English Language Arts**, students develop reports on the US watersheds and present possible solutions to problems affecting them as persuasive arguments, in multimedia formats supported by data-based evidence, and present these to a larger audience.

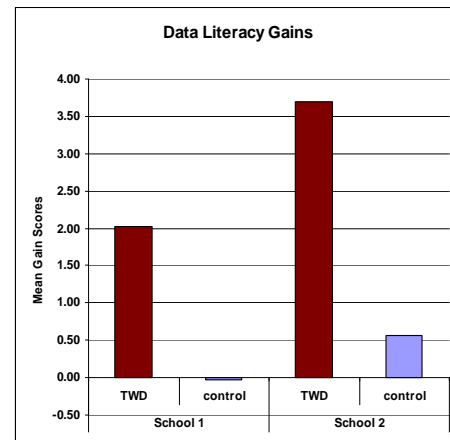
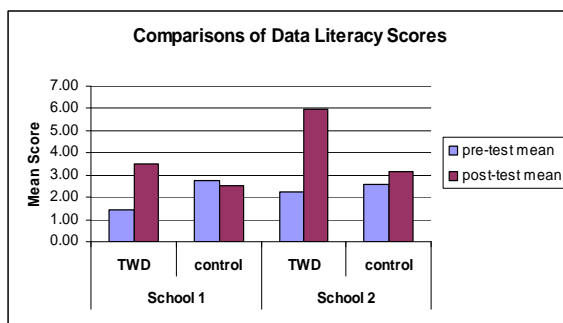
The TWD unit is grounded in a **Preparation for Future Learning (PFL)** pedagogical approach (Bransford & Schwartz, 1999). It investigates how **preparing** students to learn in one curricular context (Social Studies) with **formal learning** occurring in another (Mathematics) can improve students' deep understanding of data literacy. The project further explores extending the PFL approach to include **application** and **communications** activities common to traditional transfer sequences in still other curricular contexts (Science/ELA), leading to our calling the approach PFL+. Initial field testing of the approach suggests it enhances middle school students' data literacy, strengthening claims that PFL uncovers a general mechanism of transfer. Findings also advance the field's understanding of how Mathematics and Science can be meaningfully integrated throughout the curriculum.

### Findings

The TWD unit was subjected to both pilot testing (2007-2008) and field implementation phases (2008-2009). Formative evaluation during these phases guided the improvement of materials. Summative evaluation focused on four questions, listed below with associated findings:

1. Are teachers able to effectively implement the TWD modules?
  - *Yes, as long as there is sufficient administrative support and associated professional development.*

2. Do students who engage in the TWD modules increase their understanding of data literacy?
  - Yes; students who were exposed to the TWD curriculum had a pre/post test gain score that was three points higher (~ 20%) than comparable students in the same school who did not engage with the TWD materials. This difference was statistically significant:  $t(156.273) = 10.750$ ,  $p < .001$ , with Cohen's  $d = 1.24$  (very large effect).
  - When looking at the schools individually we found differences between them in student performance. TWD students at School 2 seemed to have learned more than those at School 1 with mean gain scores at 3.69 and 2.03, respectively. At School 2, the mean difference in gain scores between the TWD group and their 7th grade classmates was 3.135, as compared to a mean difference of 2.270 at School 1. However, effect sizes for both schools were large (1.27 and 1.00 respectively).
  - When considering questions individually, student scores improved the most on those items that required higher order thinking skills such as data interpretation across multiple tables and calculation of proportional data, providing support for the argument that the TWD materials and the PFL approach aid in the development of data literacy skills among middle school students.
  
3. Do students who engage in the TWD modules also increase their understanding of disciplinary content, particularly in Mathematics and Science?
  - Yes; pre/post testing in Math and Science showed statistically significant gains in learning disciplinary content. Due to inconsistencies in test administration, only two items could be scored on the Math test for School 2; both items showed statistically significant gains, with  $Z = 3.16$ ,  $p < .001$ ,  $d = .23$  (small effect), and  $Z = 4.70$ ,  $p < .001$ ,  $d = .35$  (small effect) respectively. Students in School 2 showed statistically significant gains across the entire Math test,  $t(24) = 4.899$ ,  $p < .001$ ,  $d = .56$  (medium effect).



- In Science, students in both schools showed statistically significant gains too, with  $t(84) = 12.665$ ,  $p < .001$ ,  $d = 1.36$  (very large effect) for School 2; and  $t(27) = 4.441$ ,  $p < .001$ ,  $d = .83$  (large effect) for School 1.
4. Can we expect, based on teacher and principal input, that this program can be scalable to a wide number of schools?
    - Yes; with the exception of Social Studies, teachers felt that the TWD unit fit into the 7th grade curriculum.
    - There were concerns about the tensions created when modules are taught using PFL, especially at the end of the Social Studies module (lack of closure).
    - A small number of teachers were concerned that some of the materials were too advanced for their students, and these concerns are addressed in our final set of materials by including alternative options for lower-achieving students.
    - Finally, teachers expressed the importance of staff development, working as a team of teachers so each knew what the other three were doing in their modules, and alignment with content standards.

## **Broader Impacts**

With its materials tested in an authentic school setting, the TWD Project

- provides a scientific basis for conducting school-based data literacy activities that cut across disciplines;
- provides a set of assessment tools that can be used to investigate students' formative reasoning as they engage in cross-disciplinary data literacy;
- provides a collection of materials and related data sets that can be used by others in the implementation of cross-disciplinary data literacy; and
- has informed the work of our Advisory Board members, who have significant influence in different areas of educational research.