NAEP Numeric Entry Usability Case Study

Usability Evaluation of Numeric Entry and Fraction Items

Presented by Theresa Wilkinson

Numeric Entry Prototype Usability Case Study

Agenda

- Project Overview
- The Problem
- Research Approach
- Key Findings
- Recommendations
- Impact

Project Overview

Role: Lead UX Strategy & Research
Organization: ETS
Duration: 20 months

Project Overview: This study evaluated the usability of the Numeric Entry (NE) item type in digital assessment platforms for Grades 4 and 8 students. The goal was to identify usability challenges, validate interaction patterns with the math keyboard (MK) and physical keyboard (PK), and inform design improvements.

Key Contributions:

- Led UX research and usability testing for Grades 4 & 8 digital math assessments.
- Collected and analyzed quantitative and qualitative data (time-on-task, keyboard usage, difficulty ratings).
- Synthesized findings into actionable design recommendations for numeric entry and fraction input to communicate insights to stakeholders.

The Problem

Students encountered challenges entering numeric and fraction-based responses in a digital environment. Issues included confusion over validation messages (VM), difficulties with the math keyboard (MK), automated comma placement, and unclear terminology in questions (e.g., “expression” and “base 10 blocks”).

Research Approach

Participants: 25 students (Grades 4 & 8).

Methods:

- Concurrent and retrospective think-aloud protocols.
- Task-based usability probes across 13 prototype items.
- Observations of physical vs. math keyboard usage, error rates, and time-on-task.

Metrics Collected:

- Count on action Physical Keyboard (PK) only, Math Keyboard (MK) only, or combination).
- Average time-on-task per item.
- Validation message occurrences.
- Student-reported difficulty.

Key Findings

Observations:

- Most students preferred using the PK for numeric entry.
- MK was helpful for fractions and mixed numbers, but sometimes time-consuming.
- Validation messages were generally understood, but caused confusion for commas.
- Average time-on-task varied from ~13 seconds (simple numeric) to ~1:19 (longer numeric entry with validation messages).

Qualitative Findings

1. Math Keyboard & Comma Automation

- Students noted benefits for fractions (easy entry using MK).
- Some students disliked the automatic comma insertion or the inability to manually adjust the cursor.
- Several students suggested guidance or tooltips for automated features.

2. Validation Messages (VM)

- Messages generally conveyed constraints clearly (allowed symbols).
- Some students misinterpreted them when trying to insert commas.
- Recommendations: add explicit guidance about auto-comma placement in the instructions or VM.

Key Findings

Qualitative Findings

3. Question Wording & Clarity

- Confusion arose around terms like "expression," "in dollars," and "base 10 blocks."
- Glossing or inline definitions recommended for clearer understanding.

4. Item-Specific Observations

- Currency items (Item 5) caused confusion about rounding and inclusion of cents.
- Fraction items (Items 2, 3, 6, 8) revealed mixed use of MK and PK, with some frustration using MK drag-and-drop.
- Numeric entry items with long numbers (Items 4, 12) challenged students regarding comma placement.

5. Retrospective Feedback

- Students appreciated visual cues (pie chart shading) and easy-to-use fraction buttons.
- Disliked: MK complexity, auto-comma restrictions, intrusive VM placement, grayed-out MK buttons.
- Suggestions: more examples, hint buttons, and optional inline definitions.

Key Findings

Key Quantitative Highlights:

- Most students used **PK only** for numeric entry, except mixed fractions where MK was used.
- Validation messages mostly triggered by comma or symbol errors.
- **Average time-on-task ranged 26 sec → 1:19 min.**
- **8–13% of students found items difficult due to usability (e.g., commas, MK).**

Item	Grade(s)	Answer	Avg Time	Keyboard Used (PK/MK/Combo)	Key Usability Notes
1 (was Item 2)	4 & 8	4/6	0:34	PK: 8, MK: 3, Combo: 13	Fraction answer; most understood question; some MK confusion
2 (was Item 3)	4 & 8	6 4/5	0:55	PK: 6, MK: 2, Combo: 16	Mixed fraction; 2 students confused by MK; 1 skipped item
3 (was Item 4)	4 & 8	13,658	1:19	PK: 25, MK: 1, Combo: 0	Validation issues with commas; half understood auto-insert; 2 frustrated
4 (was Item 5)	4 & 8	2.50	0:26	PK: 19, MK: 2, Combo: 3	Some tried to add $; wording confused 7 students; mix of decimal vs fraction
5 (was Item 6)	4 & 8	3/4	0:27	PK: 7, MK: 3, Combo: 15	Fraction entry; MK helped; 1 student preferred PK only

Key Findings

Key Quantitative Highlights:

- Mixed fraction items: MK used frequently or in combination with PK.
- Numeric-only items: PK dominant, very few used MK.
- Validation messages are minimal except when symbols were entered incorrectly.
- **Avg time-on-task 15–36 sec.**

Item	Grade(s)	Answer	Avg Time	Keyboard Used (PK/MK/Combo)	Key Usability Notes
6 (was Item 7)	4 & 8	35, 45, 55	0:26	PK: 24, MK: 1, Combo: 0	Easy numeric entry; minimal validation issues
7 (was Item 8)	4 & 8	2 3/4	0:36	PK: 6, MK: 2, Combo: 16	Mixed fraction; combo of MK and PK common; 6 students used only PK
8 (was Item 9)	8	-20	0:15	PK: 9, MK: 2, Combo: 0	Negative number; 2 students triggered validation accidentally
9 (was Item 10)	4 & 8	3	0:13	PK: 22, MK: 2, Combo: 0	Very easy; no validation issues
10 (was Item 11)	4 & 8	M+3; 13	1:10	PK: 22, MK: 0, Combo: 2	Some confusion on "expression"; 3 students skipped first box

Key Findings

Key Quantitative Highlights:

- NE items: PK dominant; commas caused most validation messages.
- Mixed answers: some combination of MK + PK.
- **Average time-on-task: 13–1:10 min depending on item complexity.**
- **Student-reported difficulty mainly from confusing wording, not usability.**

Item	Grade(s)	Answer	Avg Time	Keyboard Used (PK/MK/Combo)	Key Usability Notes
11 (was Item 12)	4 & 8	40,000	0:23	PK: 21, MK: 2, Combo: 1	Validation on commas; some used periods; 2 students confused by wording
12 (was Item 13)	4 & 8	2,4 / -4,3	0:27	PK: 23, MK: 1, Combo: 1	Minor validation issues; 5 students found graph or question type challenging
13	—	—	—	—	Summary: Numeric Entry usability overall positive; common issues: MK use, validation messages, comma entry, terminology (expression/base 10 blocks)

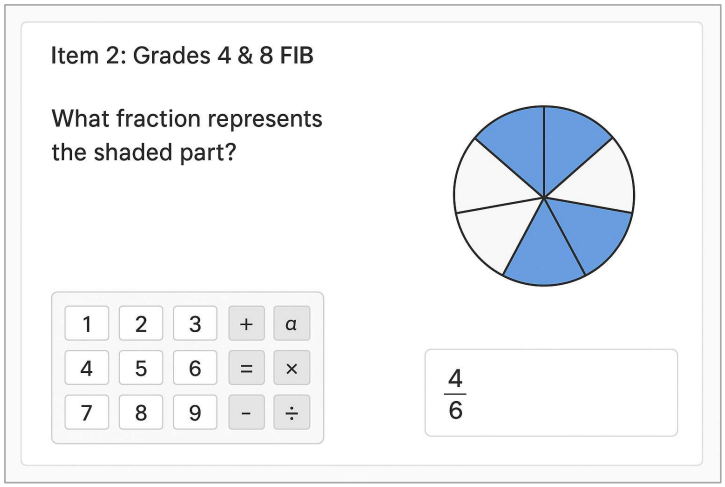
Key Findings

Quantitative Highlights:

The table below summarizes key metrics across all 13 items. It provides a high-level view of average time-on-task, keyboard usage patterns, validation message occurrences, and overall student-rated difficulty. These figures reflect the combined results for Grades 4 and 8 students and highlight trends observed across the prototype items.

Metric	**Key Finding**
Avg. Time-on-Task	0:13 → 1:19 seconds
PK vs. MK Usage	PK: 224, MK: 23, Combination: 70
Validation Messages	0 → 9 per item
Student Difficulty	Very Easy: 160, Easy: 127, Difficult: 24, Very Difficult: 2

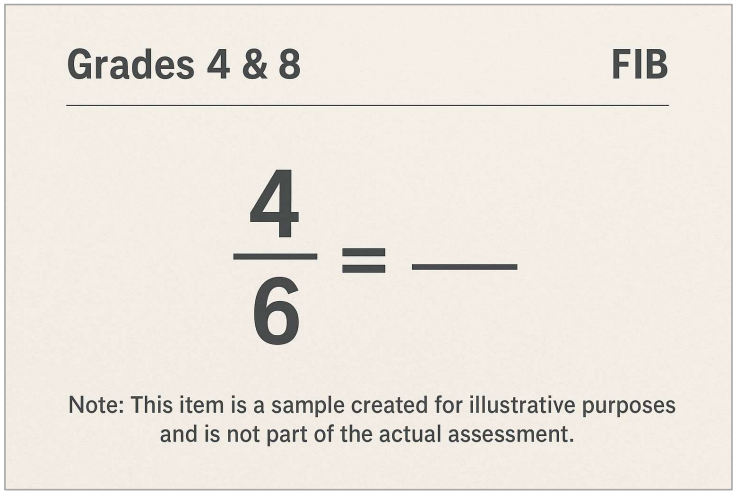
Recommendations



Note: This item is a sample created for illustrative purposes and is not part of the actual assessment.

- **Numeric Entry Fields:** Format similarly to FIB fields; allow manual comma entry.
- **Math Keyboard:** Limited MK for NE items; simplify fraction/mixed number entry.
- **Validation Messages:** Use eNAEP modal; include instructions about auto-comma and negative sign placement.
- **Scoring Considerations:** Clarify scoring rules for misplaced commas or use of periods.
- **Glossing/Definitions:** Consider inline clarifications for terms like "expression," "base 10 blocks," and "in dollars."
- **Visual Cues:** Maintain shaded areas or interactive visual aids for better understanding.

Impact



- NE implementation with the above recommendations will improve usability for Grades 4 and 8 students.
- Expected outcomes: reduced confusion, faster completion times, increased accuracy, and improved student confidence with fractions, numeric entry, and validation feedback.

Contact

Theresa Wilkinson

Email: theresaw@columbus.rr.com

Portfolio: http://www.w-edge.com/portfolio.html

LinkedIn Profile: https://www.linkedin.com/in/theresa-wilkinson-231196/