PEARSON

Drawing Response Interaction
USABILITY STUDY for PARCC

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November 16 - 19, 2015

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Twelve of the thirteen participants have a video outlining their interaction with the PARCC drawing response interaction.

All videos can be accessed in the folder Maryland Drawing Tools - Videos, found at https://pearson.box.com/s/h5xid2c4qjbnlmpzuulm4blaqyoijdsy (Note: Videos are not yet accessible).

Appendix D – Screenshots of Participant Drawings

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EXECUTIVE SUMMARY

The Partnership for Assessment of Readiness for College and Careers (PARCC) commissioned a multi-part study to determine the viability of using the drawing response interaction on the PARCC Mathematics Assessment. This study in particular focused on students with disabilities.

PARCC has over 40 interaction types on the summative assessments. Why introduce a drawing response interaction? There are several drivers to the addition of this functionality. The first is comparability. While scores across modes are comparable overall, they could be stronger at the lower grades. Students who respond to constructed response on paper can provide drawings. Feedback from students in lower grades from the mode comparability study indicated the desire for a drawing tool. Data from the scoring of paper responses indicates up to 10% of the responses include a drawing at grade 3. The Common Core State Standards (CCSS) and National Council of Teachers of Mathematics (NCTM) both indicate that students should have multiple solution paths and tools available to them.

A usability study was conducted by the Pearson's Research and Innovation Network (RIN) and Assessment Solutions and Design departments to assess the usability of a drawing response interaction type with general education and special education students with disabilities. Thirteen participants in grades 4 through 6 (during the 2015-2016 school year) participated in this study; seven students had a disability (low vision or fine motor impairment). Participants completed a series of math questions on a Chromebook or iPad that included the drawing response interaction, while observation and video recording took place.

The goal of this study was to test the usability of the drawing response interaction feature and determine if and how it assists participants in problem solving. Specifically, this study sought to compare observations from students without disabilities to students with fine motor impairments or low vision.

<u>Observations/Findings Based on the Drawing Response Interaction:</u>

- Participants from all groups (fine motor impairment, low vision, and general population) could generally use the drawing response interaction to complete basic tasks such as drawing a straight line.
- Participants from the fine motor impairment group and general population group were generally able to locate and discern between the drawing response interaction box and the equation editor textbox.
- Participants from all groups were able to erase their work using one or more of the erasing methods.

- Participants experienced difficulty identifying and using the "x" eraser tool and straight line tool.
- Participants were able to use touch and/or the mouse more effectively than the trackpad for drawing.
- The differences in drawings on the drawing response interaction and paper/pencil were likely not enough to impact scoring. The fine motor impairment group produced slightly more readable drawings using paper/pencil, and the low vision group produced slightly more readable drawings using the iPad.

General Observations:

- Participants from the fine motor impairment group were very challenged by the math content and, at times, were unable to complete tasks because of this.
- Participants from the low vision group struggled significantly with zooming to read and respond to the tasks. They had difficulty determining where they could and could not zoom.
- Participants from the fine motor impairment group and low vision group completed drawing tasks very slowly. They finished much less of the test than the general population group.

Recommendations:

- Move forward with Component 3 of Study 4.
- Evaluate making adjustments and enhancements such as increasing the point size of the drawing response interaction box border and make the straight line/pencil tools more distinguishable; adjust the "x" eraser tool to enable draggable erasing; and Include a library of shapes (rectangle, square, circle, triangle) and other tools to assist in the efficiency of using the drawing response interaction.
- Include in the Teacher Administration Manual that we recommend the use of touchscreen or mouse for students using the drawing response interaction, particularly for younger students.
- Consider adding guidance in Appendix M of the PARCC Accessibility Features and Accommodations manual around screen size minimums and browser/operating system combinations for low vision students, particularly those using 3x or 4x browser zoom. A study could be used to inform the guidance.

INTRODUCTION

The PARCC Tests assess participants' current performance on rigorous state standards for math and Language Arts; the tests are designed to not only assess for correctness, but to also look for

evidence that a participant understands and can apply their knowledge. The goal of the study was to gather feedback on a drawing response interaction from general education and special education students, which may be integrated into the PARCC assessment. Pearson is working with PARCC to deliver a flexible drawing response interaction feature to enable participants to record and submit their handwritten work and answers for math problems.

Purpose

The focus of this study was to investigate the usability and accessibility of new item interactions and functionalities on different devices and for various student groups. In particular, we wanted to determine the usability of the tool among participants who have a fine motor impairment or low vision, as compared to participants who do not have a disability.

The team recorded observations about physical interactions with the iPad and Chromebook, with a focus on the usability of the drawing response interaction.

Test Objectives

- Do participants use the drawing response interaction to support their answer?
- Do participants with fine motor impairments or low vision experience any usability, access, or processing issues with the drawing response interaction?
- Can participants identify and use the drawing response interaction features? Without moderator intervention?
- Do participants produce comparable results using the drawing response interaction and paper/pencil?

General Observation Objectives

- Do participants encounter any difficulties with the drawing response interaction? Which features cause issues?
- Do participants encounter any general technological difficulties with the iPad or Chromebook? With the touchpad or mouse?

User Profile

There were thirteen total participants, including five participants with fine motor impairments, two participants with low vision, and six participants without disabilities. Five of the participants were in fourth grade, seven were in fifth grade, and one was in sixth grade. Participants self-reported various levels of comfort with math.

Participant	**Grade**	**Gender**	**Disability**	**Use of computer/tablet for math?**	**Technology Used for Test/Input Method**	**Math Comfort Level (1=not confident at all, 5=extremely confident)**
P1	5	Female	Fine Motor Impairment	Yes--DreamBox (game)	Chromebook, Touchpad	1
P2	4	Female	Fine Motor Impairment	No	Chromebook, Touchpad	3
P3	5	Female	Low Vision	Yes--Math Facts on iPad	iPad, Touch	3
P4	6	Female	Low Vision	No	iPad, Touch	3
P5	4	Female	Fine Motor Impairment	NA	Chromebook, Touchpad	NA
P6	5	Female	Fine Motor Impairment	Yes—Math Facts	iPad, Touch	5 (Note: She may not have understood the question, as she also said she struggled with math)
P7	5	Male	Fine Motor Impairment	No	iPad, Touch	3
P8	4	Male	None	Yes--Games	iPad, Touch	4
P9	4	Male	None	Yes—Math Facts	iPad, Touch	4
P10	4	Male	None	Yes--First in Math	Chromebook, Mouse and iPad, Touch	4
P11	5	Male	None	Yes--Calculator	iPad, Touch	3
P12	5	Male	None	Yes—First in Math, PARCC	iPad, Touch	4

P13	5	Male	None	No	iPad, Touch	5

METHODS

The usability test was completed within 60 minutes. The test was designed to investigate the usability and accessibility of the drawing response interaction on different devices and for various student groups. Each participant session was organized in the same way to facilitate consistency. Three participants used the Chromebook and ten participants used the iPad. Video and audio recordings and moderator/note-taker observations were used to collect data.

Recruitment

Pearson worked closely with Trinell Bowman to identify districts to target. Anne Arundel County Public Schools and the Maryland School for the Blind were selected and primary points of contact were identified. We worked with Dr. Joshua Irzek to recruit low vision participants from the Maryland School for the Blind. We worked with Ms. Leigh Mann to recruit general education students, students with fine motor impairments, and students with low vision from Anne Arundel County Public Schools, although no students with low vision agreed to participate.

We sent Dr. Irzek and Leigh a recruiter screener letter (Appendix A) to explain who we were looking for to participate and how schools and participants could get involved. Dr. Irzek and Leigh recruited the participants and gathered parental consent forms (Appendix B).

We were able to recruit six students with fine motor impairments (five participated, as one was ill on the testing day), two students with low vision, and six general population students. Because color blindness is not reported in student files, we were not able to identify or recruit any color blind participants. We originally wanted students who had taken PARCC on a computer in the past, but only one participant (P12) met this criteria. We also wanted students who were generally on grade level; a few of the participants from the fine motor impairment group seemed to be below grade level.

Test Details

Introduction/Demographic Interview (2 - 5 minutes)

The moderator explained that the purpose of the test was to review online tools embedded in a high-stakes assessment. Participants answered questions about their past use of technology products in their math courses and their comfort with math. These questions allowed us to gain an understanding of the participant's previous use of

technology with math while giving the participant a chance to get comfortable. Last, the moderator emphasized that we are not testing the participant's ability to solve the math problems but rather their perceptions of the online tools.

Prototype Testing / Follow Up Interview (35 - 55 minutes)

The moderator explained that the participant should imagine that he/she is about to take a test online and asked them to pretend this was a high stakes test similar to one they would take at the end of the year. The moderator instructed the participant to "think aloud" as he/she completed the tasks to let us know what he/she was thinking. The test was delivered via Chromebook for four of the participants (P1, P2, P5 and P10) and via iPad for ten of the participants (note: one participant, P10, used both a Chromebook and an iPad).

Farewell (1 - 2 minutes)

When the task list was finished, participants were prompted to provide any other relevant feedback. Participants received a $25 Walmart gift card honorarium at the end of the session.

After test data had been collected, notes and video data were reviewed and coded to determine themes.

Test Environment

Usability testing was conducted during the week of November 16, 2015 at schools in the greater Baltimore area: Belvedere Elementary School, the Maryland School for the Blind, Central Elementary School and Shady Side Elementary School. Testing took place in classrooms or conference rooms, each equipped with a table and chairs for the moderator, note-taker, participant and school/district representative. For each session, the audio and screen movements were recorded using Camtasia.

Test Moderator/Observer Role

Before the session, a school representative or the moderator retrieved the participant from his/her classroom.

The moderator introduced and administered the usability test, referencing a test script as needed. The moderator introduced the participants to the assessment and informed them of the new tool. The moderator explained that we were more interested in the participant's perception of the tools than of their ability to answer the math questions correctly. The moderator explained the "think aloud" procedure for the session and answered any preliminary

questions. The moderator administered the test and asked the participants to rate the tasks completed during the session on a scale of 1 to 7, 1 being very difficult and 7 being very easy. At the end of the session, the moderator presented the participant with a $25 Walmart gift card. After the session, a school representative or the moderator walked the participant back to his/her classroom.

During each interview, the moderator operated the camera and recording software. The note-taker took notes on the feedback from the sessions. After each interview, the moderator organized and posted video footage for review.

Test Format/Prototype Overview

The test was divided into three phases.

1. In the first phase, all participants interacted with three tasks which required them to draw and shade basic shapes. These tasks were written specifically for this usability study and were designed to test whether or not participants could interact with the drawing response interaction on a basic level without instruction or a tutorial.
2. In the second phase, participants interacted with a series of tasks that required them to solve (or attempt to solve) PARCC-like questions using the drawing response interaction. These questions were based on either PARCC assessment questions in which some students included a drawing on the paper assessment or PARCC practice and sample test questions. Tasks were drawn from grade 3 items.
3. In the third phase, participants interacted with a series of tasks that required them to solve (or attempt to solve) a PARCC-like question using paper and pencil. These tasks were parallel to the items in the second phase and were included to compare paper/pencil responses to responses on the drawing response interaction.

Evaluation Measures

For each usability study objective, the following measures were used:

- Observation of users' interactions with the drawing response interaction
- Verbal dialogue, including feedback to follow-up questions

RESULTS

Thirteen participants participated in PARCC's drawing response interaction usability study. Video and audio recordings are available for twelve of the thirteen interviews (see Appendix C).

Due to motor impairments, one participant was only able to complete a very small portion of the test; we included the responses and feedback she was able to provide.

Results are broken down by general observations and group observations (fine motor impairment, low vision, and general population).

Previous Technology Usage with Mathematics

Prior to beginning the usability test, participants were probed regarding their use of technology with math.

- **4 of 13 participants reported no use of technology in math**
- **8 of 13 participants reported using some sort of technology in their math courses**
    - 6 participants used technology for math games or math facts
    - 1 participant used technology for PARCC
    - 1 participant used technology for calculations
- **1 of 13 participants did not report her technology usage**

General Perceptions of the Drawing Response Interaction

Below is an overview of general observations from the study for all three groups (fine motor impairment, low vision, general population). Group-specific observations can be found in the Population-Specific Drawing Response Interaction Observations section below.

General Observations

Do participants successfully use the drawing response interaction to support their answers?

- In general, participants could use the drawing response interaction for simple tasks.
    - Participants using the Chromebook (P1, P2, P5, P10) experienced more difficulty than participants using the iPad, regardless of impairment.
    - 12 of 13 participants were able to draw a line using the drawing response interaction.
        - P5 (fine motor impairment group) was unable to draw a line using a trackpad.
- Participants in the fine motor impairment group (P1, P2, P5, P6, P7) struggled with the content of the questions. With question modification, these participations were generally able to use the drawing response interaction.
- Participants in the low vision group and general population group generally understood the content and were able to use the drawing response interaction.

Do participants encounter any difficulties with the drawing response interaction features? Which features are most difficult?

- Pencil/Straight Line Tool

    - All participants correctly identified the pencil tool.
    - 2 participants correctly identified the straight line tool (P4, P13).
    - 6 participants did not correctly identify the straight line tool (P7, P3, P8, P9, P11, P12).
        - 4 participants thought it was an eraser (P8, P9, P11, P12).
        - P6 thought someone else controlled the computer switching between the pencil and straight line tool.
- "x" Eraser Tool
    - 8 participants recognized the "x" tool as an eraser tool but they struggled to get it to work correctly and a few participants were unsuccessful and perceived the tool to be broken (P1, P7, P8, P9, P10, P11, P12, P13).
        - "I thought it would be an eraser but I can't figure it out." (P8)
    - 1 participants was not sure what the tool does (P2).

Do participants encounter any general technological difficulties with touch or mouse?

- Chromebook
    - Participants struggled to use the Chromebook (trackpad and/or mouse) to complete the tasks.
    - Participants struggled to draw shapes they were satisfied with.
- iPad
    - Participants were generally able to use the iPad to draw shapes.
    - Some participants encountered minor issues with unintentional zooming upon double clicking an icon.

Do participants run out of room?

- The fine motor impairment and low vision groups tended to run out of room more frequently than the general population group.

Do participants locate the response area for drawing and text components?

- Fine Motor Impairment Group
    - P5 had difficulty locating and staying within the drawing response interaction box.
- Low Vision Group
    - P3 and P4 had difficulty seeing the borders of the drawing response interaction box and equation editor textbox.
- General Population Group
    - All participants were able to locate the drawing response interaction box and equation editor textbox.

Do participants produce comparable results using the drawing response interaction and paper/pencil?

- For all groups, the differences in drawings on the drawing response interaction and paper/pencil were likely not enough to impact scoring. See Appendix D for side-by-side comparisons of drawing response interaction and paper/pencil drawings for each participant.
- Fine Motor Impairment Group
  - 5 of 5 participants preferred paper/pencil for basic tasks (P1, P2, P5, P6, P7).
  - Paper responses were generally slightly easier to read.
- Low Vision Group
  - Both participants preferred the iPad (P3, P4).
  - iPad responses generally were easier to read.
- General Population Group
  - 3 of 6 participants preferred the iPad (P8, P9, P11).
  - 2 of 6 participants preferred paper/pencil (P10, P13).
  - 1 of 6 participants said it depended on the ask (P12).
  - Paper and iPad responses were comparable.

Task-Specific Observations

- Basic Tasks (Tasks 1-3)
  - 0 participants used the straight line tool for Task 1.
  - 1 participant used the straight line tool for Task 2 (P4).
  - 4 participants increased the width of the pencil for shading in Task 3 (P2, P3, P8, P9).
- Computer PARCC-like Tasks (Tasks 4-9)
  - Most participants struggled with the tools in the equation editor textbox. In general, they had more difficulty identifying and navigating the equation editor tools than the drawing response interaction tools.
- Paper/Pencil PARCC-like Tasks (Tasks 10-12)
  - Readability of responses was generally comparable on paper/pencil compared to the drawing response interaction.
  - Participants showed their computational work on paper/pencil but did not generally do so on the drawing response interaction or in the equation editor textbox.

Population-Specific Drawing Response Interaction Results

Fine Motor Impairment Group

There were five participants with fine motor impairments (P1, P2, P5, P6, P7). Three of the participants used a Chromebook/trackpad (P1, P2, P5) while two of the participants used an iPad (P6, P7). One participant (P5) was only able to attempt one task, as it was extremely

difficult for her to use the trackpad; she had very limited verbal skills, so she was unable to share verbal feedback with us. One participant (P2) became a bit frustrated and chose to end the session early.

Tasks Attempted

Task	1	2	3	4	5	6	7	8	9	10	11	12
P1	X	X	X	X	X							
P2	X	X	X	X		X				X		
P5	X											
P6	X	X	X	X							X	
P7	X	X	X	X		X			X		X	

Task Overview

Tasks 1-3

- 4 of 5 participants (P1, P2, P6, P7) completed these tasks.
- 3 of 5 participants (P1, P6, P7) did not know what a curved line was.
- 1 participant (P2) did not know what a rectangle was.

Tasks 4-12

- Participants struggled greatly with math content. The moderator modified the questions for most of the participants.

Paper/Pencil vs iPad/Chromebook Preference

Do participants prefer to draw on the iPad/Chromebook or on paper? Which is easier?

- Tasks 1-3:
  - 5 of 5 participants preferred paper/pencil (P1, P2, P5, P6, P7).
    - "Because on the screen the kids have less space to draw, on the paper/pencil, they have more space to draw." (P1)
    - "You don't have to press any buttons...and [the paper] has a lot of space." (P6)
- Task 11:
  - 1 participant preferred the iPad (P7).
    - "It's easier to change the color." (P7)

Which looks better (i.e. which was easier to read/interpret)?

- The differences in the drawings on the drawing response interaction and paper/pencil were likely not enough to impact scoring.
- For the Chromebook participants (P1, P2, P5), the paper/pencil responses were slightly more readable than the Chromebook responses.
    - P5, who was unable to draw responses on the Chromebook using the trackpad, was able to draw responses on paper.
    - P1 and P2 expressed frustration with using the trackpad to draw on the Chromebook.

- For the iPad participants (P6, P7), the paper/pencil responses were relatively comparable to the iPad responses.

Navigation

Participants who used the trackpad struggled more with navigation than participations who used touch.

Are participants able to sufficiently navigate the drop-down features? Click the correct button?

- Overall, participants were able to navigate the drop-down features and select the correct button.
- One participant (P5) experienced difficulty selecting the correct button. She had the most severe motor impairments.

Are participants able to successfully complete the click, drag, release sequence?

- Participants were able to complete the sequence on the iPad.
- Participants struggled more with the sequence on the Chromebook/trackpad.
    - P5 was unable to complete the sequence.
    - P1 and P2 struggled at times with the sequence.

Do participants run out of room?

- 4 of 5 participants ran out of room or expressed that they want more room (P1, P2, P5, P7).
    - Participants ran out of space on Task 1 (P5), Task 2 (P1), Task 3 (P1), Task 4 (P1), Task 6 (P2, P7), and Task 9 (P7).
    - Task 2 is difficult “because the square (drawing response interaction box) is so small.” (P1)
    - “I think they need to make the box bigger so you’ll be able to fit all of the tables and the people.” (Task 4, P1)
- 1 of 5 participants experienced difficulty remaining in the drawing response interaction box when she was drawing her responses (P5).

Do participants experience difficulty with shading?

- Overall, participants using the iPad were able to shade effectively, while participants using the Chromebook experienced more difficulty with shading.

Low Vision Group

There were two participants with low vision (P3, P4). Both participants used an iPad. Both participants used the browser zoom feature at its maximum magnification and held the iPad very close to their faces to read and respond. P3 inverted the colors on the screen.

Tasks Attempted

Task	1	2	3	4	5	6	7	8	9	10	11	12
P3	X	X	X	X								
P4	X		X	X	X			X			X	

Task Overview

Tasks 1-3

- Both participants were able to complete these tasks on paper and on the iPad.

Tasks 4-12

- Participants generally understood the content.

Paper/Pencil vs Chromebook/iPad Preference

Do participants prefer to draw on the Chromebook/iPad or on paper? Which is easier?

- Tasks 1-3:
  - Both participants preferred the iPad (P3, P4)
    - "I think it's easier to draw a straight line on the iPad...for the pencil, you can't really see what you're drawing. Well, I can't really see what I'm drawing." (P3)
    - I would use [the iPad] because you can push the line and move it around and make it larger."
- Task 11:
  - P4 preferred paper.
    - "I just drew instead of having to zoom in and all that stuff." (P4)

Which looks better (i.e. which was easier to read/interpret)?

- The differences in the drawings on the drawing response interaction and paper/pencil were likely not enough to impact scoring.
- The iPad responses were slightly more readable than the paper/pencil responses.

Navigation

Are participants able to navigate adequately?

- Zooming
  - Both participants struggled with zooming.
    - P3 and P4 unintentionally drew in the drawing response interaction box when they were intending to zoom or scroll.
    - P3 and P4 thought they could zoom anywhere on the screen, including from within the drawing response interaction box and equation editor box.
  - Both participants disliked having to zoom.
    - "I don't really like having to zoom. Like when I'm reading this to get to the other side, I have to zoom, then let go, then zoom." (P4)
    - "I had to zoom a lot of times. On the test, it would take time to do this." (P4)
- Navigating to the drawing response interaction box
  - Both participants had difficulty seeing the borders of the drawing response interaction box.
- Identifying the drawing response interaction box and equation editor textbox
  - Both participants were able to zoom to find the drawing response interaction box and equation editor textbox.

Are participants able to find the drop-down buttons?

- Both participants were able to find the drop-down buttons.
- P3 could not see the difference between the pencil and straight line tools.

Do participants run out of room?

- P3 ran out of room on Tasks 2 and 3.

General Population Group

There were six general population participants without fine motor impairments or low vision. One participant (P10) used the Chromebook/mouse for a few tasks and the iPad for the rest of the tasks, while the rest of the participants used the iPad.

Tasks Attempted

Task	1	2	3	4	5	6	7	8	9	10	11	12
P8	X	X	X	X	X	X	X	X		X		
P9	X	X	X	X	X			X		X		
P10	X	X	X	X	X			X			X	
P11	X	X	X	X	X	X	X		X		X	
P12	X	X	X	X	X				X	X		
P13	X	X	X	X						X		

Task Overview

Tasks 1-3

- All participants were able to complete these tasks on paper and on the iPad.
- The participant using the Chromebook/mouse (P10) struggled more than the participants using the iPad.

Tasks 4-12

- Participants generally understood the content and were able to use the tools.

Paper/Pencil vs Computer Preference

Do participants prefer to draw on the computer/iPad/Chromebook or on paper? Which is easier?

- Tasks 1-3:
    - 4 of 6 participants preferred the iPad (P8, P9, P11, P12).
        - "I can make a perfectly straight line, and it takes less time to erase." (P8)
        - "It's easier to shade in than to do it with a pencil, cause with a pencil, you can't make the brush thicker." (P8)
        - "I think the iPad would be easier because if you want to draw straight and curved lines with different colors, you'd have to get different colored pencils and it would take longer." (P11)
    - 2 of 6 participants preferred paper/pencil (P10, P13).
        - "Paper [is] easier cause the mouse can sometimes swivel faster than normal." (P10)
            - *NOTE:* P10 was using a Chromebook/mouse for this question
    - 1 of 6 participants said it depended on the task (P12).

        - "...it depends, making a straight line, it would be probably be [the iPad], but a curved line is easier on paper and pencil." (P12)
- Tasks 5-12:
    - Task 11
        - "Paper, because I'm used to having paper, and I usually have more space on paper than on a tablet or computer." (P10)

Which looks better (i.e. which was easier to read/interpret)?

- The differences in the drawings on the drawing response interaction and paper/pencil were likely not enough to impact scoring.
- The paper/pencil and iPad responses were generally comparable.

Navigation

Are participants able to navigate adequately?

- All participants navigated adequately.
- All participants identified the drawing response interaction box and the equation editor textbox.
- All participants were able to click the buttons and complete the click, drag, release sequence.

Do participants run out of room?

- P9 ran out of room on Task 4.
- P10 ran out of room on Task 8.

FINDINGS & RECOMMENDATIONS

This section discusses positive results and potential issues that became apparent during the study and provides actionable design recommendations to increase the usability of the drawing response interaction.

Overall, most participants were comfortable interacting with the drawing response interaction for simple tasks. The fine motor impairment group and low vision groups faced more challenges than the general population group.

Summary of Findings
Overall, all groups were generally able to complete basic tasks using the drawing response interaction. Participants were able to use touch more effectively than the trackpad for drawing.

The fine motor impairment group was generally able to navigate the drop-down features and select buttons. All but one participant was able to complete the click, drag, and release sequence. All but one of the participants ran out of room on one or more tasks. Many of the participants struggled with the math content. The participants using the iPad were able to use the drawing response interaction with more ease than the participants using the Chromebook/touchpad.

The low vision group experienced the most difficulty with zooming. They struggled to identify where they could and could not zoom, and they were frustrated by the amount of time it took to zoom. Zooming negatively impacted the number of tasks they were able to complete. They struggled to see the edges of the drawing response interaction box. Their drawings were more easily readable on the iPad.

The general population group was able to navigate adequately, was able to identify the drawing response interaction box and textbox, and was able to easily click the buttons and complete the click, drag, and release drawing sequence. On average, they were able to complete more tasks than the fine motor impairment and low vision groups.

Overall Recommendations

- Move forward with Component 3 of Study 4.
- Evaluate making adjustments and enhancements such as: increasing the point size of the drawing response interaction box border, making the straight line/pencil tools more distinguishable, adjusting the "x" eraser tool to enable draggable erasing, and including a library of shapes (rectangle, square, circle, triangle) and other tools to assist in the efficiency of using the drawing response interaction.
- Include in the Teacher Administration Manual that we recommend the use of touchscreen or mouse for students using the drawing response interaction.
- Consider adding guidance in Appendix M of the PARCC Accessibility Features and Accommodations manual around screen size minimums and browser/operating system combinations for low vision students, particularly those using 3x or 4x browser zoom. A study could be used to inform the guidance.

Participant Feedback

The following are suggestions provided by our participants. These suggestions are based off of verbal feedback shared by the participants during the testing sessions.

Drawing Response Interaction Features

- Pencil/Straight Line Tool
    - Create more distinction between the pencil and straight line tool icons.

    - P4 suggested adding color to the tool icons to help distinguish between the two.
- "X" Eraser Tool
    - Create a draggable eraser functionality.
    - "I would make it so that if you drag it over the line, instead of just tapping the line." (P8)

Other Feature Considerations

- Shapes
    - Consider adding a library of shapes or a tool to increase the efficiency of using the drawing response interaction.
    - P13 wanted a "shape fixer" that would make the shapes he drew more accurate.
- Paint Bucket
    - Consider adding a "paint bucket" tool to help students shade shapes.
    - "Is there a way there's a paint bucket that could fill [the shape] in? Select the color, press the corner, and it would fill in." (P11)

Navigation and Space

- Location/navigation of response areas
    - Create thicker borders around the response areas to enable low vision students to better locate these areas.
- Space
    - Create larger response areas to enable students with fine motor impairments to more easily and fully show their work.
- Buttons
    - Increase the size of the buttons to enable all students to select the correct buttons.
    - Consider adding colors to the buttons for easier identification.

Low Vision Modifications

- Enable font-size increase so students do not have to zoom.
- Enable text-to-speech.
- Increase the default thickness of the pencil to enable students to better see what they are drawing.

APPENDIX A - LETTER OF RECRUITMENT

Dear Local Accountability Coordinator:

Pearson, on the behalf of PARCC, Inc. is pleased to invite students who are in Grades 4 and 5 to participate in a research study designed to inform the future development of test questions for the Partnership for Assessment of Readiness for College and Careers (PARCC) consortium.

We conduct Usability Testing with people; students, teachers, administrators, and parents. One-on-One usability testing with an experienced researcher allows us to get a clear understanding of how accessible, usable, and useful our products are. Student confidentiality is maintained at all times and their identities will not be shared with anyone.

The focus of this study is to investigate new item interactions and functionalities' usability for various student groups on different devices and accessible by students with special needs. The following research questions will be addressed through the use of PARCC-like mathematics questions:

· Does the drawing response interaction allow students to more fully and authentically demonstrate their knowledge and skills of mathematics and differentiate between those students with and without the knowledge/skills being measured?

· Is the drawing response interaction intuitive? Usable?

· Is the drawing functionality (palette) sufficient? Is there a need for instructions/tutorial?

· What are the usability, access, or processing issues for special populations, in particular, students with fine motor impairments, low vision and color blindness?

We Need Students:

We are looking for students who are functioning at or near grade-level in mathematics and who took the PARCC assessment online. We will be selecting a mix of students who have one or more of the following documented characteristics, along with a few students who have none of these characteristics:

· Low Vision – Students who used 2x-5x magnification (200% or more) on the recent PARCC online assessments.

· Colorblind or color spectrum shifts

· Fine motor impairments, who can use a mouse or paper

Each session will take approximately 60 minutes and student participants will be offered a $25 Walmart gift card for their participation. All students who participate will require consent from their parent or guardian and/or approval by the school district. Parents and teachers are welcome to ask any questions in advance of the study. Someone from the school or central office should be designated to observe the sessions in person.

Where: Various Elementary Schools

When: November 9-20, 2015

Materials: Pearson will be providing a laptop or tablet for the students to use and a camera for recording the session. If there is other hardware students need, please let us know. We will require a room with internet connectivity, and preferably a phone as well.

There will be three to five, 60-minute sessions each day. If any of those days will not work, please let us know. We will likely be moving from building to building each day or two, depending on how many students are available at a particular location.

How to Participate:

Please provide the following information using the attached Excel document to Rebecca Gilchrist at rebecca.gilchrist@pearson.com by Thursday Oct 15, 2015. For every three students with disabilities you recommend, please include one student who does not have a disability in one of the three areas of focus. If your students meet the requirements for our study, we will contact the coordinator to schedule each student's session.

Teacher's Name
School District
School Building
Coordinator's name (who should we work with to schedule, e.g., building administrator, teacher)
Coordinator's email
Coordinator's phone
Student's First Name
First initial of Last Name
Grade (4/5)
Gender (M/F)
Did the student take the PARCC assessment online?
What type of device? (e.g., tablet, laptop)
Preferred mode of entry? (mouse or touch)
Which accessibility features, if any, did the student use? (e.g., color contrast, browser zoom)
What, if any, customized settings or equipment did the student use (e.g., mouse controls, alternative mice or keyboards)?
What, if any, assistive technology did the student use?
Any other test accommodations not previously mentioned (e.g., scribe, large screen, extended time, text to speech)

Colorblind (y/n)
If Yes, then describe (e.g., red/green, color spectrum)
Low Vision (Y/N)
If yes, then what magnification level (e.g., 3x) and any color perception or light sensitivity considerations?
Fine Motor Impairment (Y/N)
If yes, please describe student's ability to draw simple shapes and to write by hand.
Other Impairments (Y/N) Please list if yes (e.g., learning disability).
Is the student classified as English Language Learner (ELL)? (Y/N) If yes, what level?

Thank you very much for your interest in our study. We look forward to working with you and your students. If you have questions, please contact Rebecca Gilchrist via email at rebecca.gilchrist@pearson.com.

APPENDIX B – PARENTAL CONSENT FORM

Pearson
3075 W Ray Rd, Suite 200
Mail Stop 210
Chandler, AZ 85226
Fax: 480.457.7408
www.PearsonSchool.com

Re: PDRE PARCC Drawing Tool Usability Testing

Dear Parent or Guardian of Student Participant,

In an effort to improve our educational products, Pearson Education ("Pearson") is committed to obtaining feedback from students who use or might use our products. The more input users or potential users provide during the design process, the more likely our products will meet our users' needs.

Pearson is seeking participation and feedback from your child on educational products as part of a Research Study called the PDRE PARCC Drawing Tool Usability Testing. For this study, your child will be asked to use an iPad or computer application to perform predetermined tasks and to answer online survey questions about the product and participate in interviews. The Research Study session will last approximately 60 minutes.

Your child's participation in the Pearson PDRE Equation Editor Cog Labs/Usability Testing Study is optional, and you are under no obligation to have your child participate. However, should you agree to have your child participate, this letter sets forth the expectations and activities required by the participants in this Research Study, and sets forth the terms and conditions applicable to these activities:

1. The study is being conducted in the state of Maryland. Within each state, locations will vary and will be communicated with the parent or guardian prior to the study. Locations will be in public buildings and may include, but not be limited to:

- Public schools
- Schools for the blind
- Learning Disabilities Association Facilities

- Universities
- Pearson Offices, where available

2. As part of this Research Study, your child's first and last names will be collected in order to organize and differentiate data between research participants. However, this information will be only used for that purpose and Pearson will destroy this information upon completion of the Study.

3. During your child's participation in the Research Study, your child will not encounter any more risk than is normally associated with using an interactive online learning application. Your child may receive possible educational and learning benefits from his or her participation in this Study, and as a result of your child's participation, educational products, in general, should benefit.

4. Though Study results may be shared with you or your child throughout the Research Study, you waive any right to inspect and/or approve of the Work Product or how the Work Product may be used by Pearson.

5. Should you agree to allow your child to participate in this Research Study, you acknowledge that your child will have access to Pearson Confidential Information. As such, you agree your child will not disclose any Pearson Confidential Information in any manner, in whole or in part, to any other party, or to use such Pearson Proprietary Information except for purposes of participating in the usability study. For purposes of this letter, "Pearson Confidential Information" means any information disclosed to your child by Pearson, either orally or in writing, relating to any products, services, or software code or functionalityowned, developed or being developed by or for Pearson or its affiliates, which specifically includes Pearson's Equation Editor and any materials related to the Equation Editor including, but not limited to, source code, processes, designs, research, marketing methods or distribution plans, except to the extent that such information is already generally known or available to the general public or is disclosed by Pearson to third parties without restriction on disclosure.

6. The following are considered Permitted Uses of Pearson's Confidential Information by your child as a research participant: (i) to evaluate and/or test the Pearson Drawing Tool as instructed by Pearson during this Cog Lab Study, or (ii) for any other specific purpose that your child has been authorized to do by Pearson. Anything you're your child does with Pearson's Confidential Information outside the scope of the Permitted Uses will be considered a breach of this Agreement, unless your child has received prior written authorization from Pearson.

7. At your direction or at your child's request, your child may withdraw or terminate his or her participation in this Research Study at any time; however, Pearson will own all right, title and interest to any Work Product that has been created or submitted by your child at the time of your child's withdrawal from the Study.

8. You agree that any copyright or other intellectual property rights in the responses to the research activities described in this letter, including any suggestions, concepts or ideas that are provided to Pearson in the course of your child's participation in this Research Study, will be owned by Pearson and are hereby

assigned to Pearson. You or your child will not be entitled to any compensation, royalties or attribution if Pearson utilizes any such responses, writings, suggestions, concepts or ideas in its products. You further agree that for copyright purposes, Pearson shall own all right, title, and interest in the audio, video, and/or screen recordings as a result of your child's participation in this Research Study.

9. As full compensation for your child's participation and for the rights granted in this Release, Pearson agrees to provide your child with a $25.00 Walmart gift card at the end of his or her participation.

If you have any questions regarding this release letter or your child's participation in these activities, please call Rusty Brandt at 480-457-7429. If you agree to allow your child to participate in this Research Study pursuant to the terms set forth in this letter, please electronically sign and date below and submit the signed copy by the date of your child's scheduled study session. Please make a copy of this letter for your records.

We look forward to your child's participation!

Sincerely,

Rusty Brandt

Senior Researcher

Pearson Design Research & Efficacy

ACKNOWLEDGED AND AGREED:

I am the parent or guardian of the person whose name appears below and who is younger than eighteen years old. I permit the participation of the person referred to below pursuant to the terms set forth in this letter. I also agree that the minor will be accompanied to the usability study by a responsible adult. These provisions shall carry the same force as if I had agreed to them on my own behalf.

_____ Mailing Address:

_--_____

Child's Name (PRINT)

_____ _____

Name of Parent/Guardian (PRINT)

_____ _____

Signature of Parent/Guardian Date

_____ _____

Email Address Telephone Number

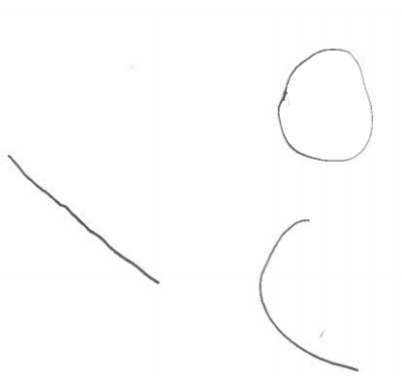
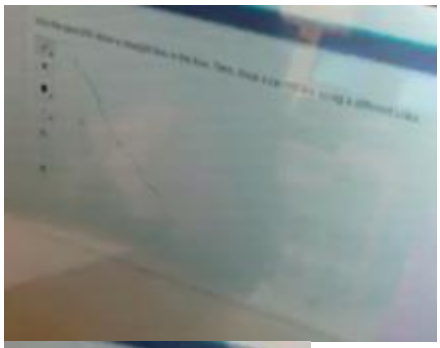
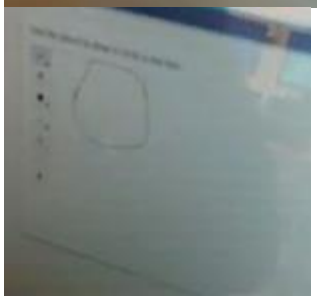
Appendix C – Video Recordings

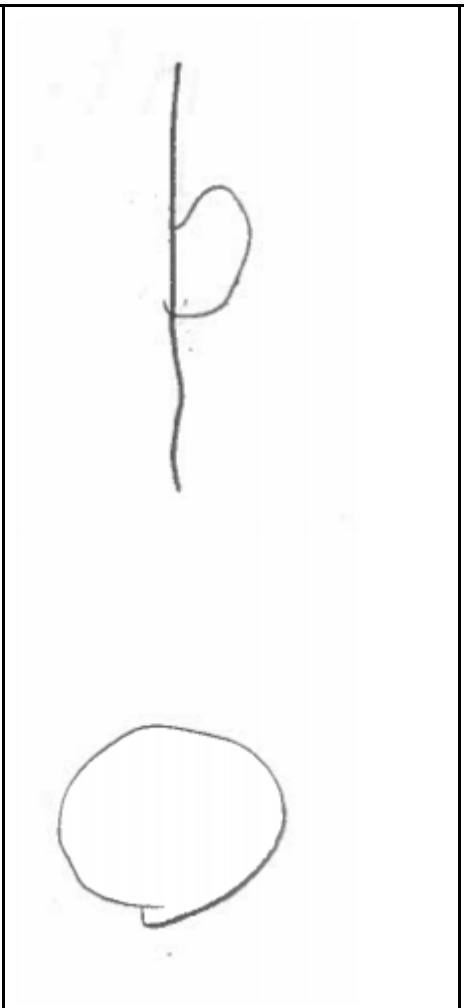
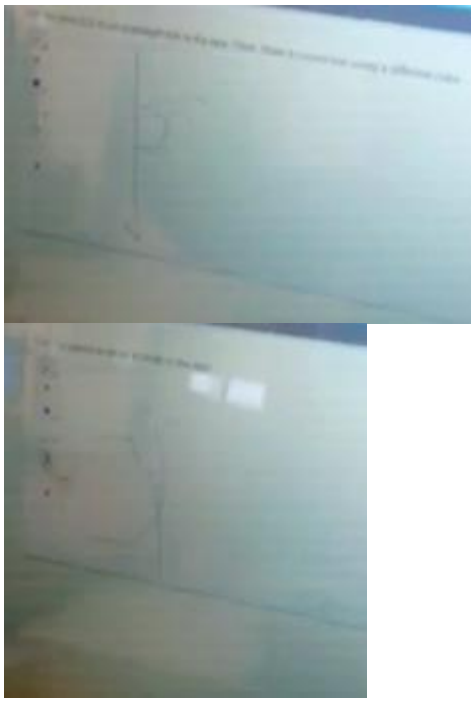
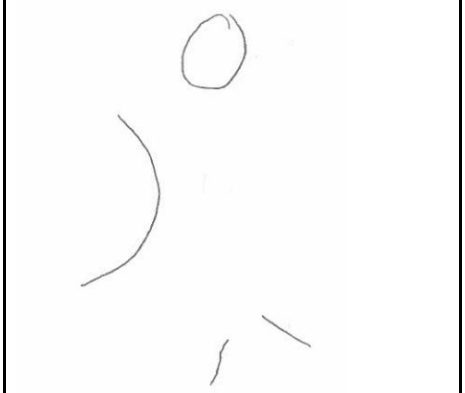
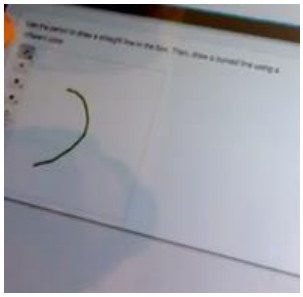
Twelve of the thirteen participants have a video outlining their interaction with the PARCC drawing response interaction.

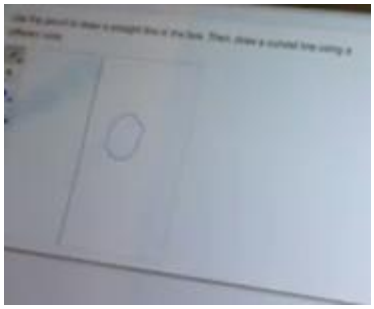
All videos can be accessed in the folder Maryland Drawing Tools - Videos, found at https://pearson.box.com/s/h5xid2c4qjbnlmpzuulm4blaqyoijdsy (Note: Videos are not yet accessible).

Appendix D – Screenshots of Participant Drawings

Fine Motor Impairment

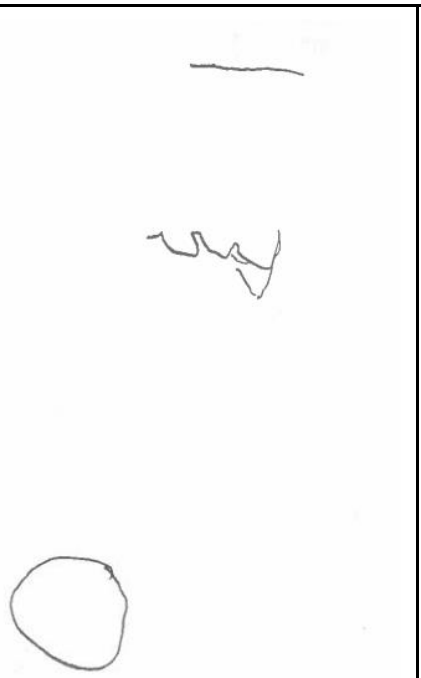
Participant	Paper/Pencil	Chromebook/iPad
P1		 

P2		
P6		

P7		

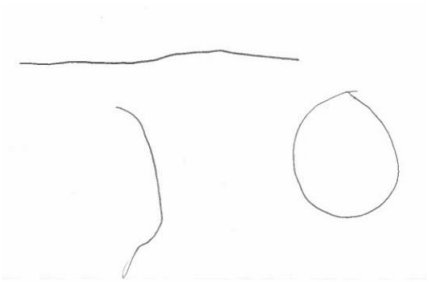
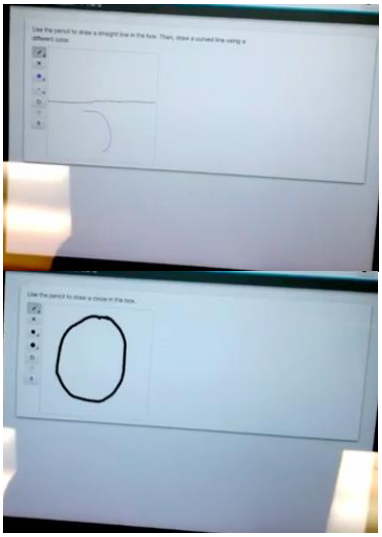
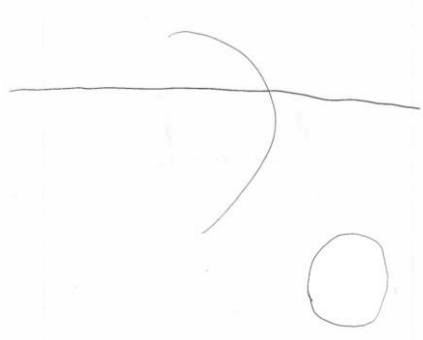
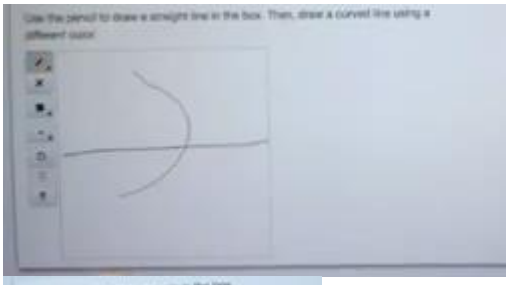
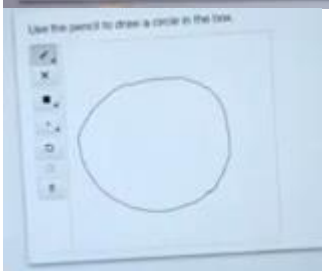
Low Vision

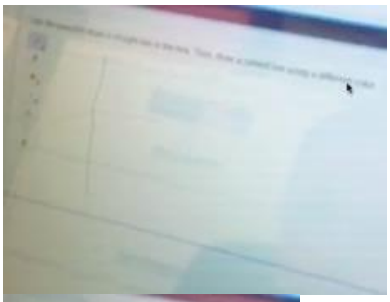
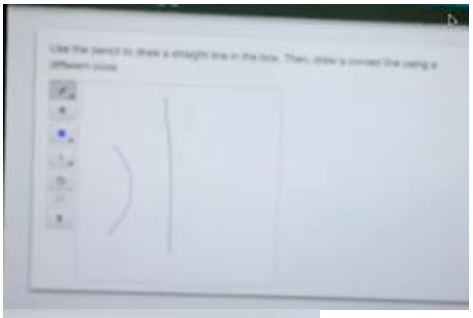
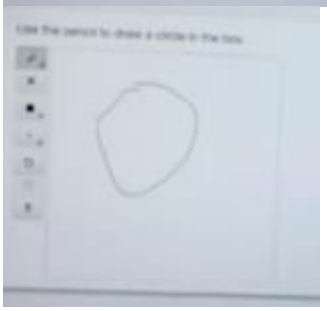
Participant	Paper/Pencil	

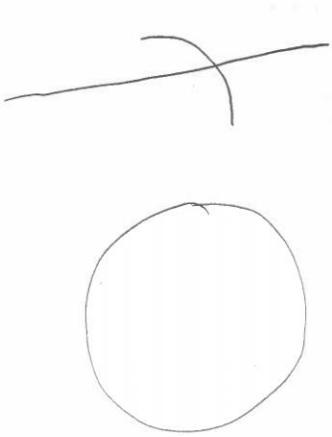
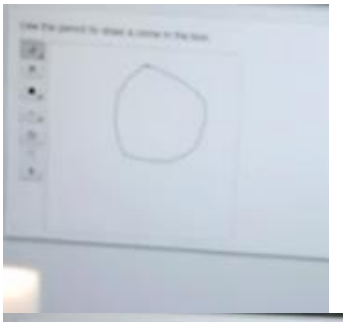
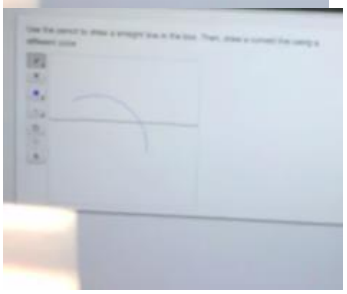
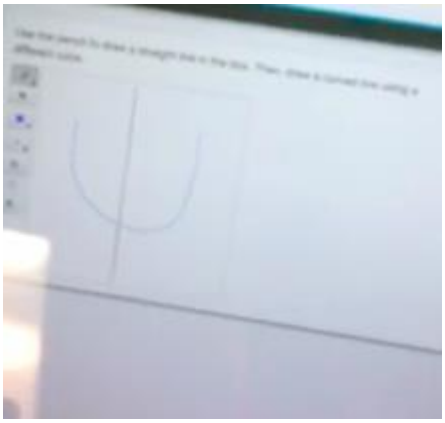
P3		We were not able to record this session.
P4		

General Population

Participant	Paper/Pencil	iPad/Chromebook

P8		
P9		 

P10		Chromebook:  iPad:  
P11		

P12		 
P13		

APPENDIX E – MODERATOR'S GUIDE

November PARCC Drawing Tool CogLab:
Moderator's Guide

Session Introduction

1. Introductions – introduce team members: Rusty, Elizabeth

2. Room Setup – we will be recording the session. We will capture video of the participant, the keyboard, and the computer screen.

3. Purpose – today you are going to be looking at a tool to help students show their work and answer math questions.

4. Feedback – we will be going through a series of activities. We want you to think out loud and feel comfortable sharing what you're thinking. If you are feeling confused, or you have expectations that are not being met, we want to hear about that. Be as honest as possible. If you think something is awful, please say so. Don't be shy, you won't hurt anyone's feelings. We are very interested in understanding your ideas and opinions about what you are about to see, so please share freely.

5. Our goal is to make well-designed products for everyone, so it's important we understand what you think and what does and doesn't work for you.

6. Any Questions?

Overview

Demographic Interview: Do you, or have you ever use a computer to complete math assignments?

Scenario: Imagine that you're about to take a test online. You will be expected to show all of your work within the test on the computer.

Potential Other Questions:

- What type of alternative device are you using?

Tasks

- Do participants successfully use the drawing response interaction to support their answer? Without moderator prompts?
- Do participants encounter any difficulties with the drawing response interaction features? With which features did the participant have the most difficulty?
- Do participants encounter any general technological difficulties with touch or mouse? Do they have difficulty manipulating the mouse and/or using the touch screen?
- Do participants intuitively know how to use the drawing response interaction features (pencil tool, straight line tool, line weight tool, color tool, eraser tools)? If not, which features did they not intuitively understand?
- What are the usability, access, or processing issues for special populations, in particular, students with fine motor impairments, low vision, and color blindness?
- Do participants use the different features/palettes of the tool, such as the undo/erase tools (if needed)?
- Do participants run out of room in the drawing response interaction? Do they erase to construct smaller graphics to fit the drawings in the box?
- Do participants locate the response area for drawing and text components? Is there a preference for placement? Is it problematic to have the locations move?
- Do users identify any other functionality they would like to see added to the drawing tool?

General Questions:

1) *Tell me what you're thinking.*
2) *How would you use these tools to solve the problem?*
3) *Is it working like you expect it to?*
4) *Is there anything you find confusing or frustrating?*
5) *Is there anything you'd like the tool to do that it doesn't do now?*
6) *What's frustrating you? What's causing you to struggle?*
7) *Is there anything missing, or would you like something to act/behave differently?*
8) *What would you add to the drawing tool in order to help you solve this problem?*
9) *What do you think of the location of the tool?*

Watch for

- Issues with clicking/touching buttons
- Issues with click, drag, release sequence
- Issues with scrolling
- Issues locating drawing box and/or textbox

Part 1: Basic drawing response interaction tasks (Tasks 1-3)

Task 1: Draw a Straight Line, Curved Line

a. [After login] Look over this page and tell me what you think you can do here.

   1) *How would you expect to be able to use this tool?*
   2) *What do you think each of the buttons are for?*
   3) *What would you expect to be able to do?*
   4) *Is there anything you find confusing?*

b. Go ahead and do what the question asks.
   1) *What colors do you see in the palette (how many)?*
   2) *If the participant uses the straight line tool, was it faster? was it easier?*

   Watch for

- Use of straight line vs pencil tool
- Number of colors participant can see in the palette
- Any difficulties using the drop-down menus or selecting buttons
- Any difficulties with the click, drag, release sequence

c. Now, complete the same task on paper.
   1) *Was it easier or harder completing it on paper?*

   Explain to participants: If you were doing it on paper, wouldn't be able to-- just do your best. Don't worry about how they will score them-- precision (on paper, wouldn't have to be exact).

Task 2: Draw a Circle

a. Complete what the question asks.
   1) *What do you think of your circle (are they satisfied with the accuracy)?*

b. Now, complete the same task on paper.
   1) *Was it easier or harder completing it on paper?*

Task 3: Draw a Rectangle, Shade / Draw a Circle, Shade

a. Complete what the question asks.
   1.) ***If the participant uses the straight line tool****, was it faster? was it easier? Do you understand the difference between the pencil and straight line tool?*
   2.) ***If participant does not use the straight line tool,*** *have them try. What do you think about the pencil and straight line tool? Is one easier to use than the other? Why?*

3.) ***If the participant uses the weight tool for shading****, what did you think of the weight tool?*
4.) ***If the participant does not use the weight tool****, ask them to use it. What did you think of that?*

Watch for

- Use of straight line vs pencil tool
- Use of weighted tool for shading
- Difficulty with shading

Part 2: PARCC-like items, Computer/iPad, Online Response (Tasks 4-9)

Task 4: Picnic Tables

a. Here's an actual math problem you might encounter in a test. Go ahead and solve it as you would normally, if you were taking this test at school.
   1.) ***If the participant uses the straight line tool****, was it faster? was it easier? Do you understand the difference between the pencil and straight line tool?*
   2.) ***If participant does not use the straight line tool,*** *have them try. What do you think about the pencil and straight line tool? Is one easier to use than the other? Why?*

Watch for

- Use of straight line vs pencil tool (for picnic table drawing)
- Use of weighted tool (for marking the people at the tables)
- Difficulty with shading
- If/how the participant uses the drawing box and textbox
- **VISUALLY IMPAIRED: If they find the equation editor box easily**

Task 5: Fractions

a. Complete what the question asks

Watch for

- Whether or not the participant understands the question
- If/how the participant uses the drawing box and textbox
- **VISUALLY IMPAIRED: If they find the equation editor box easily**

Task 6: Toy Cars

a. Complete what the question asks

Watch for

- Whether or not the participant understands the question
- If/how the participant uses the drawing box and textbox
- **VISUALLY IMPAIRED: If they find the equation editor box easily**

Task 7: Areas of Tables

a. Complete what the question asks
    1.) ***If the participant uses the straight line tool****, was it faster? was it easier? Do you understand the difference between the pencil and straight line tool?*
    2.) ***If participant does not use the straight line tool,*** *have them try. What do you think about the pencil and straight line tool? Is one easier to use than the other? Why?*

Watch for

- Whether or not the participant understands the question
- Whether or not the participant uses the straight line tool
- If/how the participant uses the drawing box and textbox
- **VISUALLY IMPAIRED: If they find the equation editor box easily**

Task 8: Picture Array

a. Complete what the question asks
    1.) ***If the participant struggles to draw the array,*** *what's frustrating you? What's causing you to struggle?*

Watch for

- Whether or not the participant understands the question
- Whether or not the participant uses the weighted tool
- Whether or not the participant runs out of room or has to erase and start over due to lack of room
- If/how the participant uses the drawing box and textbox
- **VISUALLY IMPAIRED: If they find the equation editor box easily**

Task 9: Beads

a. Complete what the question asks
    1.) ***If the participant does not complete part B,*** *are you done? Is there anything else you would do?*

Watch for

- Whether or not the participant understands the question
- If/how the participant uses the drawing box and textbox
- Whether or not the participant puts his/her answer in the Part B box
- **VISUALLY IMPAIRED: If they find the equation editor box easily**

Part 3: PARCC-like items, Computer/iPad, Paper Response (Tasks 10-12)

- How do students solve problems on paper?
- What are the main differences between solving on paper, and solving on computer/iPad?

Tasks 10-12

Say: For this next set of problems, we're going to ask that you solve them using paper/pencil, as you would with a traditional test you might take at school.

a. Complete what the question asks on paper
   1.) ***If the participant does not draw on the paper,*** *can you create a drawing to illustrate what you are thinking?*
   2.) Do you think you would draw the same thing if you were working on a computer instead of on paper?
   3.) Is it easier to draw on the computer/iPad or on paper? Which do you prefer?
   4.) What were you able to do on paper, that you weren't able to do on the computer/iPad?

Watch for
- Whether or not the participant understands the question
- Whether or not the participant uses the paper/pencil to draw

Post-Interview Questions

[If not addressed in earlier conversations about drawing tool]

a. Are there any online math tools, apps, etc. that you've used before that help you explain your work, or solve math problems?

   1.) If so, what are they? How do they help you??
   2.) What can we do to make it easier for you to show your work/solve the problems?
   3.) [If not already addressed earlier] What would you add to the drawing tool in order to help you solve math problems?