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Imagination Station (Istation): Universal Screener and Inventory Instruments Interface Development for Grades PK-1

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Imagination Station (Istation): Universal Screener and Inventory Instruments Interface Development for Grades PK-1

Cassandra Hatfield • Lindsey Perry • Deni Basabara • Saralyn J. Miller • Erica Simon • Leanne Ketterlin-Geller

Southern Methodist University

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Department of Education Policy & Leadership
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PO Box 750114
Dallas, TX 75275-0114
Contact information: rme@smu.edu

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Abstract

In this technical report, Research in Mathematics Education (RME) describes the design and development of 21 computer interfaces used for the Imagination Station (Istation) Universal Screener and Mathematics Standards Inventory assessments for students in pre-kindergarten, kindergarten, and Grade 1. The computer interfaces are designed to deliver assessment items in a student-friendly format. This technical report outlines the process used to design and develop the interfaces and to finalize the interface functions and corresponding student actions for each interface. The design process included research and conceptualization of the interfaces, designing the interfaces, and conducting usability tests to revise and further develop the interfaces based on student interactions. Additionally, we describe the external review process used to evaluate the appropriateness of the computer interfaces and finalize them for both assessments.

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Imagination Station (Istation): Universal Screener and Inventory Instruments Interface Development for Grades PK-1

Introduction

The Imagination Station (Istation) Universal Screener and Mathematics Standards Inventory (Inventory) for students in pre-kindergarten (PK) to Grade 8 are two instruments designed to help teachers identify students struggling to learn critical mathematics content and to inform teachers' instructional decision-making. The universal screener is a computerized adaptive formative assessment used to (a) identify if students are at risk for not meeting grade-level curricular expectations and (b) determine the intensity of instructional support students may need to be successful. Teachers administer the universal screener to all students in fall, winter, and early spring. Teachers then administer the inventory to all students identified as at-risk on the universal screener. The inventory is a computerized formative assessment that provides educators with a detailed list of the mathematics content standards for which students have and have not demonstrated proficiency. Teachers can use student performance data from the inventory to guide instructional decision-making by identifying content needing additional instructional focus during whole group and small group instruction and/or during individual intervention lessons.

The computer-based testing platform differs for students in Grades 2-8 and PK-1. The universal screener and inventory assessments for Grades 2-8 use a single interface and students respond to selected response (i.e. multiple-choice) items with four responses. In contrast, items on both PK-1 formative assessments are more interactive in nature. In addition to the selected response format, the PK-1 assessments incorporate a number of other item formats (e.g., drag and drop, clicking or tapping, and keypad entry) that assess the targeted constructs in an interface supported by audio instructions. The purpose of this technical report is to describe the PK-1 interface development process, detailing tasks completed by the interface development committee and features of the 21 interfaces.

Computer Interface Development for PK-1

The universal screener and inventory item banks contain more than 3,000 assessment items altogether, sufficient for generating three equivalent alternate forms of each assessment to be administered in the fall, winter, and spring. Students can use an iPad or computer to respond to the assessment items, which are delivered using 21 interfaces. The different interfaces assess each content standard by allowing students to interact with the assessment items in ways that are developmentally appropriate with respect to students' reading skills, fine/gross motor skills, and hand-eye coordination. We describe these interfaces in more detail later in this report.

Interface Development Committee

Eight committee members contributed to the interface development process. In the following paragraphs we describe their qualifications and relevant prior experience.

Committee Member 1 holds a Doctoral degree in Educational Leadership with emphases in measurement, assessment, and research methodology, a Master's degree in Special Education with a focus on assessment, and Bachelor's degrees in Spanish and English. She has worked on multiple federally funded longitudinal studies designed to examine the effectiveness and efficacy of reading intervention programs for struggling readers in Grades K-3. She currently coordinates the development of multiple mathematics assessments for Grades PK-8.

Committee Member 2 holds a Doctoral degree in Educational Leadership and a Bachelor's degree in Biology. She has 20 years of combined experience in education as a high school science teacher, trained administrator, researcher, and university professor. She is currently an Associate Professor of Education Policy and Leadership, and conducts research on mathematics instructional and assessment practices to support student achievement.

Committee Member 3 holds a Doctoral degree in Human Development and Education, a Master's degree in Human Development and Education, and a Bachelor's degree in Child and Adolescent Development. She has eight years of post-secondary teaching experience. She currently works as a Program Officer for Heising-Simmons Foundation for Early Education. She has conducted research in mathematics education and has experience developing mathematics curricula.

Committee Member 4 holds a Master's degree in Educational Leadership and Policy Studies and a Bachelor's degree in Mathematics. She has four years of combined experience as a mathematics teacher and interventionist in Grades 4-7. She has experience as a Mathematics Assessment Specialist, Mathematics Curriculum Specialist, and as the Assistant Director of Mathematics for a state department of education. She has served as a reviewer for the National Assessment of Educational Progress. She is a currently pursuing her Doctoral degree in Educational Policy and Leadership.

Committee Member 5 holds a Master's degree in Special Education and a Bachelor's degree in Environmental Horticultural Science. He has seven years of experience developing alternate assessments for students with significant cognitive disabilities in Grades K-12. He is currently a Research Assistant on multiple mathematics assessment projects for Grades PK-8.

Committee Member 6 holds a Master's degree in Childhood Education and a Bachelor's degree in Government. She has experience teaching elementary and middle school. She has also taught courses in Teacher Education and Child Development at the postsecondary level. She is currently pursuing her doctoral degree.

Committee Member 7 holds a Master's degree in Educational Administration, a Bachelor's degree in Interdisciplinary Studies with an emphasis in Mathematics, and credentials in Administration (K-12), Mathematics (Grades 4-8), and Conflict Resolution. She has experience as an Elementary Mathematics Specialist and as a mathematics teacher for Grades 4–8. She has also worked on a variety of national, state, and local assessment projects. She is currently an Assessment Coordinator for a mathematics research unit.

Committee Member 8 holds a Master's degree in Educational Administration, a Bachelor's degree in Education, and credentials in General Education (EC-4), Gifted and Talented, and English as a Second Language. She has seven years of combined teaching experience in kindergarten and 4th grade.

Interface Development Process

The interface development committee, along with graphic artists and computer programmers, worked to determine and develop the most appropriate interface and item format for assessing each PK-1 content standard for the universal screener and inventory assessments. Over a period of five months, they designed 21 interactive computer interfaces and documented the corresponding functions and student actions. The interface development process consisted of three steps, which were completed prior to writing the items for the universal screener (Perry, Hatfield, Basabara, & Ketterlin-Geller, 2014) and inventory (Hatfield, Basaraba, & Ketterlin-Geller, 2015):

1. Research and conceptualize how students commonly interact with computer and iPad applications to complete mathematics-related tasks.

2. Draft pictorial interface designs, describe their functions, identify corresponding student actions, and develop these interface designs to fully function on a computer and iPad.

3. Conduct usability tests to revise the interfaces, their functions, and corresponding student actions based on students' feedback and actions observed during the usability tests.

Step 1: Research and interface conceptualization

In Step 1, the interface development committee worked with an early childhood mathematics expert who has experience in developing assessments for PK-1 using interactions with computer-based online formats. During this process, the committee researched approximately 50 online early mathematics activities, assessments, and games. These possible assessment methods were identified using mathematics education resources (e.g., NCTM, school district recommendation lists, etc.). After initial review, some of the identified resources were not selected for further analysis due to the number of mouse clicks required to complete the task or the incompatibility with use of an iPad. Furthermore, some activities focused more on the reward aspect as a game rather than the math skill (e.g., answer a math equation right and then get 10 seconds to play a non-related game) and were also not selected for further analysis. Of the 50 initially reviewed, 38

were documented for further analysis using a template created for this project. The template identified:

- Website
- Game content
- Mathematical tasks that students were required to complete and a description of how the tasks might be used to assess mathematics content standards
- Possible content alignment with the Istation PK-1 content standards
- Overall evaluation of the interface quality, including advantages and disadvantages of the interface to inform Istation PK-1 interface development

Next, the interface development committee met as a group to brainstorm and draft possible interfaces to assess PK-1 mathematics content standards for the universal screener and inventory assessments. Sample items were written to provide additional information about the capabilities that would be necessary within each potential interface.

The interface development committee used the results of the brainstorming meeting to facilitate the initial interface design meeting with Istation's project team. The following topics were discussed: (a) the fine motor skills of students in Grades PK-1 and the implications of those skills for the interfaces, (b) the extent to which students in Grades PK-1 were likely to be familiar with computers and iPads, (c) the need to create interfaces that were engaging but not distracting (i.e., avoid irrelevant images, information, or unnecessary student actions), and (d) the need for a singular interface theme to minimize student distraction and unnecessary cognitive load. We presented various themes to Istation, focusing on the *grocery store* theme as a familiar context that was unlikely to introduce bias for a majority of students. Staff presented sample item drafts and capabilities that could be used to assess numerous mathematics content standards. Sample items were grouped by one of three possible student actions on the computer or iPad: click or tap, keypad response, and drag and drop.

Step 2: Interface design and development

In Step 2, Istation used the sample items to report the interfaces they could create by producing professional images. Using this information from Istation, the interface development committee further studied mathematics content standards for each grade level to (a) determine which interfaces could be used to assess those standards, (b) document the function of each interface and corresponding student action, (c) draft a pictorial model of each interface, and (d) draft additional sample items that would be presented in that interface. The committee shared these interface ideas with the Istation project team in order to further conceptualize and finalize each interface.

The development and refinement of the interfaces was iterative. The Istation team and the interface development committee worked together to maximize the interactions for students within each interface. As a result, some interfaces remained the same throughout the design and development phases, while other more complex interfaces were divided and redesigned to allow

for the desired functions. The results of this iterative design and development process are illustrated in Appendix A, in which rectangles on the left represent the originally proposed interfaces and rectangles on the right represent the final interfaces with the desired and technically possible functionalities.

Of the 18 interfaces originally proposed (a) five were separated into two or more interfaces, (b) five were collapsed and refined into fewer interfaces, and (c) eight remained unchanged. As an example of the first case, consider the originally proposed *Patterns* interface that, after further discussion with the Istation development team and review of the mathematics content standards, was separated into *Pattern Construction*— students use a set of objects to construct a pattern that mirrors a given pattern—and *Pattern Completion*— students use a set of objects to complete a given partially complete pattern. The *Measurement* interface is an example of the second case, whereby two originally proposed interfaces—*Measurement* and *Measurement Multiple Choice*— were combined into one interface that would allow students to use non-standard units of measurement (e.g., loaves of bread, jars of peanut butter, etc.) to measure the length or height of a given surface. Finally, some interfaces, such as *Tens and Ones* and *Shapes*, were technically possible within one interface and required only minimal modifications.

Step 3: Usability testing

In Step 3, Istation conducted interface usability tests with students to (a) examine the extent to which interfaces functioned as intended, (b) observe how and to what extent students were able to perform the actions required to demonstrate a response within the interface, (c) identify student actions/behaviors that may interfere with their ability to respond to an item within a given interface (e.g., wrists resting on the iPad screen due to children's small hand size made the drag and drop feature challenging in some interfaces), (d) evaluate the functionality of the static components of the computer-based assessment delivery system (e.g., OK button to submit responses, button to return to previous item, etc.), and (e) determine the extent to which student actions required for the assessment using the computer or iPad were developmentally appropriate and intuitive.

Istation staff conducted usability tests, compiled the results and modified the interfaces accordingly. Istation provided the interface development committee with a usability test summary report; RME project staff made changes to the item language based on the report. Upon completion of the first usability test, it was determined that a total of 21 interfaces would be utilized to develop the assessment.

The usability tests resulted in the following overall modifications to the interfaces: (a) add an audiovisual feature to cue students that the OK button had been clicked/tapped and that the next question is loading, (b) enable a scrolling feature within the internet browser to allow students to scroll within the testing window, and (c) redesign the keyboard to resemble a telephone keypad (i.e., three rows of three digits, read from the top left, plus 0) to facilitate easier data entry for students.

We describe modifications to each interface based on usability testing in Table 1.

Table 1 *Usability testing adjustments*	
Interface	Adjustments made
Pattern Construction	Added cue color of blue to indicate drop zone*
Pattern Completion	Added cue color of blue to indicate drop zone*
Measurement	Revised task directions to increase clarity Modified the surface length students were measuring to make it more realistic Added cue color of blue to indicate drop zone*
Dial Response, Static	Modified the size and spacing of the arrows
Dial Response, Dynamic	Modified the size and spacing of the arrows
Ordering Length	Added a visual indicator of where the longest/shortest items should be placed on the screen Added cue color of blue to indicate drop zone*
Ordering Numbers	Limited the number of items to be ordered to a maximum of seven numbers Adjusted snap tolerance** Added cue color of blue to indicate drop zone*
Ordering Pictures	Adjusted snap tolerance Added cue color of blue to indicate drop zone*
Tens and Ones	Changed from drag/drop to click/tap Removed functionality of completing an equation
Image Multiple Choice	Added cue color of blue to indicate when a response is selected
Counting	Added cue color of blue to indicate drop zone*
Shapes	Made shapes translucent so students can see overlap Added the availability to request outlines as a guide in the drop zone Adjusted snap tolerance Added cue color of blue to indicate drop zone*
Expressions	Added cue color of blue to indicate drop zone*
Media with Response	Added cue color of blue to indicate when a response is selected
Multi-Select	None
Rotation	None
Sorting	Removed items that included preplaced equations when students were required to sort equations without column labels Added cue color of blue to indicate drop zone*
Graphing (Horizontal)	Added cue color of blue to indicate drop zone*
Graphing (Vertical)	None
Number Line	Added cue color of blue to indicate drop zone*
Addition	Added cue color of blue to indicate drop zone*

Note. *Drop zone: An identified area within the computer-based testing platform where students can place items as responses.

**Snap tolerance: Set to give students flexibility horizontally and/or vertically when they place an item in an identified drop zone to allow for development and refinement of motor skills in Grades PK-1. Snap tolerances vary somewhat by grade level.

Finalization of the Interfaces

After the modifications were made based on usability test results, the interfaces were further refined during the item writing process for both the universal screener and inventory assessments for Grades PK-1. Item writers requested additional interface functionalities to accommodate items, as needed. Additionally, item writers and item reviewers provided feedback on the appropriateness and functionality of the interfaces. All feedback was reported to Istation, who used the information to modify the interfaces and conduct additional usability tests to ensure that these changes did not hinder students' ability to interact with the interfaces. Istation worked to polish the visual appearance of the interfaces to make the finished product student-friendly. Table 2 describes the 21 finalized interfaces, the capabilities of each interface, and the corresponding student actions.

Table 2
Finalized Interfaces

Interface	Capabilities	Student Actions
Pattern Construction	A pattern is shown; students use the sample pattern to create another pattern with the same unit, replacing the elements.	Drag and drop
Pattern Completion	A pattern is shown; students add to the pattern.	Drag and drop
Measurement	Students measure objects using non-standard units; students' answer is scored based on the number of non-standard units used to measure a given object or keypad entry indicating the number of non-standard units used	Drag and drop; keypad entry
Dial Response, Static	Money: An image of money is shown, and students answer by clicking on the dial arrows to indicate the amount; only 2-digit answers are accepted	Click/tap
	Picture: An image is shown, and students answer the problem by clicking on the dial arrows; between one and three digit answers can be accepted	Click/tap
	Text: A problem is shown, and students answer the problem by clicking on the dial arrows; between one and three digit answers can be accepted.	Click/tap
	Time: A time on an analog clock is shown, and students answer the problem by clicking on the dial arrows.	Click/tap
Dial Response, Dynamic	A given number of bell peppers are shown; students use the up and down arrows to show a new amount based on the problem.	Click/tap
Ordering Length	Images are shown; students order from shortest to longest or longest to shortest.	Drag and drop
Ordering Numbers	Numbers are shown on shopping bags; students order the numbers from least to greatest or greatest to least.	Drag and drop

Interface	Capabilities	Student Actions
Ordering Pictures	Images are shown; students order the pictures based on the problem.	Drag and drop
Tens and Ones	Students use the arrows to add/subtract tens and ones based on a given situation.	Click/tap
Image Multiple Choice	Images are shown; students select one image as the correct answer.	Click/tap
Counting	Students build a number using base-10 block objects or drag a certain number of objects into a shopping cart.	Drag and drop
Shapes	Students duplicate an image using multiple shapes from a sample image shown.	Drag and drop
Expressions	A problem is given; students create or complete an expression or equation.	Drag and drop
Media with Response	Text with Image Embedded: A problem is shown on the screen with an image embedded; students answer the question by selecting one of two to four response options or type in their answer using a keypad.	Click/tap; keypad entry
	Text: Text is shown on the screen; students answer the question by selecting one of two to four response options or types in their answer using a keypad.	Click/tap; keypad entry
	Animation: An animation is shown on the screen; students answer the question by selecting one of two to four response options or type in their answer using a keypad.	Click/tap; keypad entry
Multi-Select	Images are displayed; students select multiple answers.	Click/tap
Rotation	Students use the move and rotate button to move two shapes together to create another shape.	Click/tap
Sorting	Images are shown; students sort the images into two to four boxes based on attributes.	Drag and drop
Graphing (Horizontal)	Students drag and drop fruit to create a horizontal bar graph based on a shopping list.	Drag and drop
Graphing (Vertical)	Students click arrows to construct a vertical bar graph.	Click/tap
Number Line	Students drag and drop numbers to the number line, placing cards on the correct hash marks.	Drag and drop
Addition	Students model a contextual situation or equation by dragging and dropping objects into a workspace. Students may also be asked to type in an answer with the keypad.	Drag and drop; keypad entry

Conclusion

The purpose of this technical report was to describe the Istation PK-1 Universal Screener and Inventory interface development for use with the computer and iPad. We described the interface development process by outlining (a) the exploratory and interface conceptualization processes; (b) identification of interface names, functions, and student actions; and (c) the revision and finalization process. Finally, we described the features, functions, and required student actions associated with the 21 finalized interfaces.

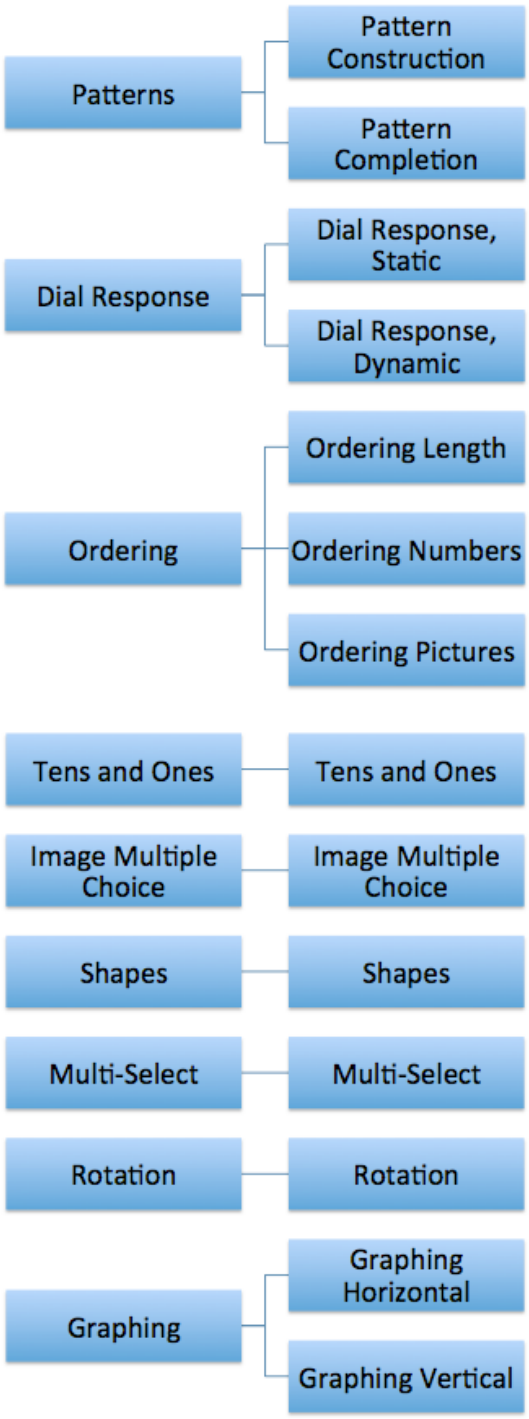
References

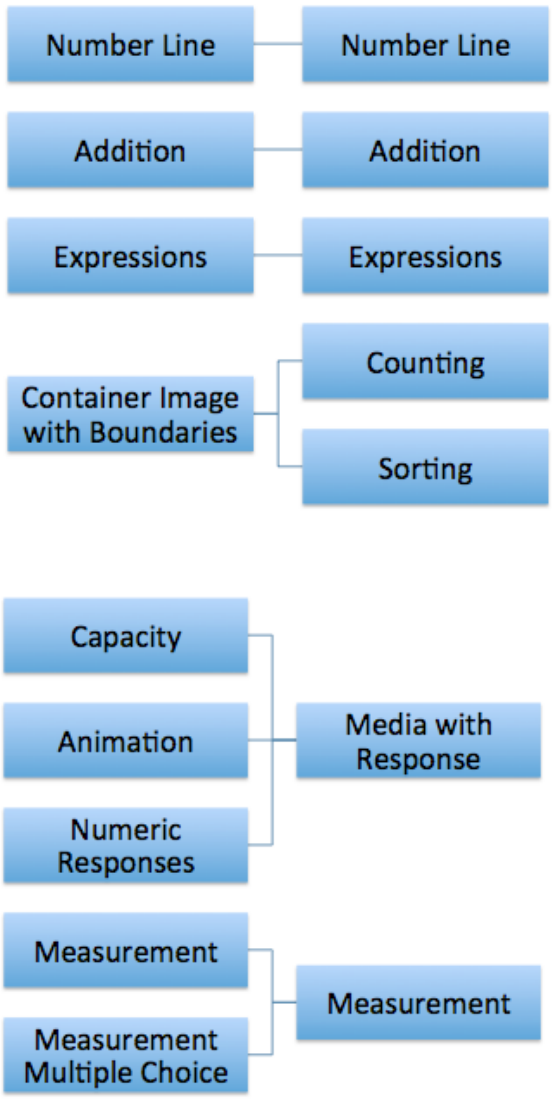
Hatfield, C., Basabara, D., Perry, L., & Ketterlin-Geller, L. (2015). *Imagination Station (Istation): Universal screener instrument development for grades PK-1*. (Technical Report 15-01). Dallas, TX: Southern Methodist University, Research in Mathematics Education.

Hatfield, C., Basabara, D., & Ketterlin-Geller, L. *Imagination Station (Istation): Inventory item bank development for grades PK-1*. Manuscript in preparation. Dallas, TX: Southern Methodist University, Research in Mathematics Education.

Appendix A – Interface Design & Development

This figure illustrates the decisions made collectively by the interface development committee and Istation about the proposed interfaces. Rectangles on the left represent the originally proposed interfaces and rectangles on the right represent finalized interfaces.




Number Line
Number Line
Addition
Addition
Expressions
Expressions
Container Image with Boundaries
Counting
Sorting
Capacity
Animation
Numeric Responses
Media with Response
Measurement
Measurement Multiple Choice
Measurement