SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
Options for Language	Options for Expression	Options for Sustaining Effort
Options for Comprehension	Options for Executive Function	Options for Self Regulation

Select a UDL Guideline section to learn more.

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SPREADSHEET MATH

LEARNING GOAL

Options for Perception	**Options for Physical Action**	**Options for Recruiting Interest**
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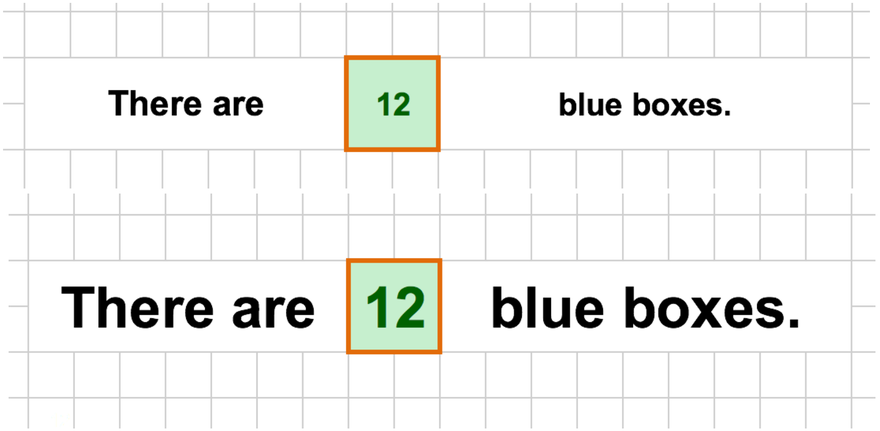
Built into spreadsheet software is the ability to **scale text** to fit each individuals' needs. With a few simple clicks, users can change weights, sizes, and colors of type to best fit their unique needs, although the activities have been designed with large, legible type already included.



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SPREADSHEET MATH

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The decision upon the spreadsheet's **manual refresh** comes from two distinct ideas. For one, it allows the spreadsheet to be used at the user's own pace. Mathematics is often thought of as fast-paced and stressful. By eliminating this anxiety, we can ensure more meaningful learning experiences.

The refresh command ⌘**Enter** can also be mapped to an external accessibility switch (pictured right) for easy access without the need for fine motor movements needed for a shortcut. The prototype also utilizes **StickyKeys**, a native function by Apple that allows shortcut keys to be pressed asynchronously for ease of use.

Press ⌘+ to generate a new set of blue boxes

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SPREADSHEET MATH

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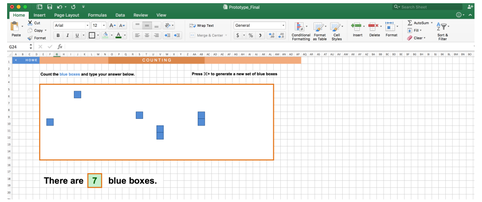
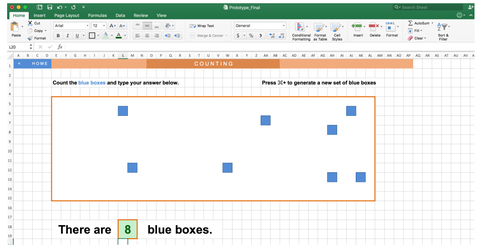
The ability to **customize one's virtual environment** plays at a large advantage to recruiting the user's interest. Spreadsheets, especially those not designed for a specific purpose, can allow users to explore its capabilities and limitations – in turn creating scientific exploration of not only the software, but its content.





Everything inside the exercises can be altered, scaled, formatted, colored, stretched, and moved.

The lessons are designed to be living, breathing, playgrounds to be altered, explored, and challenged.

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SPREADSHEET MATH

LEARNING GOAL

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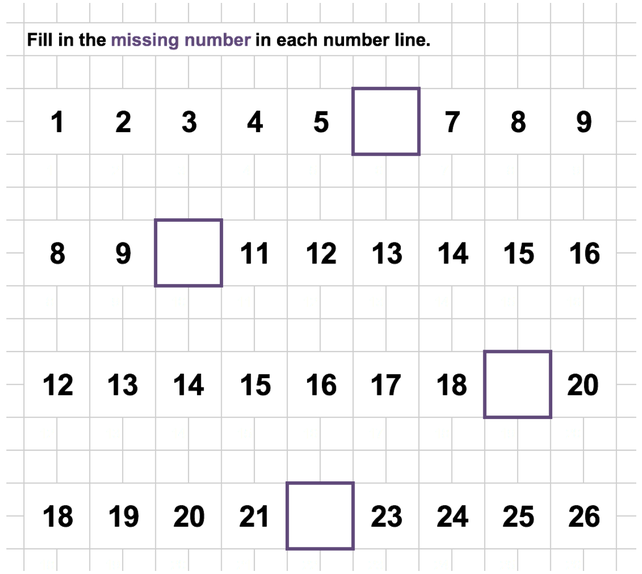
The ability to decode mathematical symbols and expressions is at the core of fundamental number sense. Each exercise in the prototype is focused on reinforcing the user's comfortability with mathematical symbols – minimizing irrelevant text, unwanted descriptions, and imagery. Numbers are presented clearly, with formatting and text-to-speech options provided by spreadsheet software.



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SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
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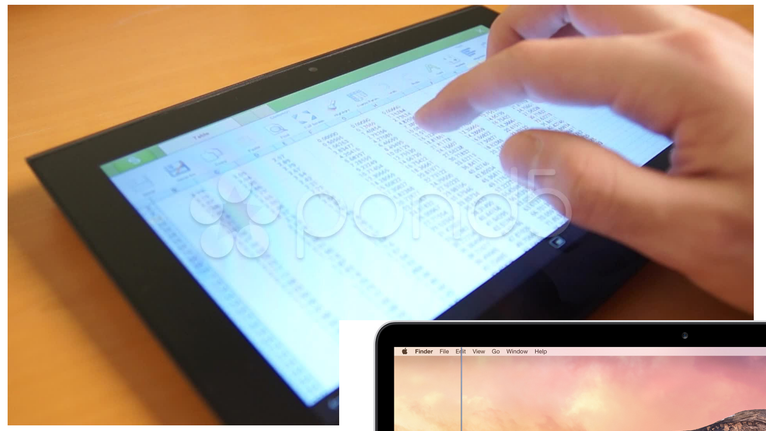
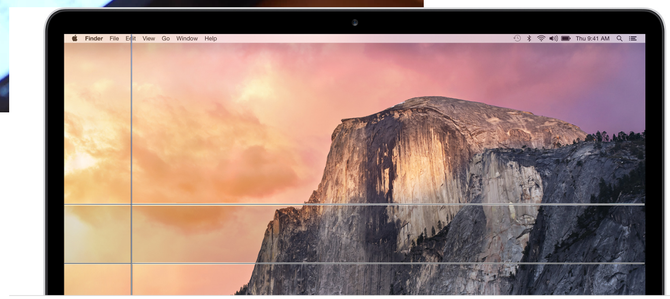
The ubiquitous nature of spreadsheets allows for their content to be **displayed on almost any modern day screen** – and to be manipulated using any digital or human input device. This means that the same lesson can be used by one user on an iPad, one with a specialized hands free retina-tracking computer, and one user on a traditional house and keyboard.



Easy touch screen capabilities



Apple accessibility scanner built-in for one touch navigation

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SPREADSHEET MATH

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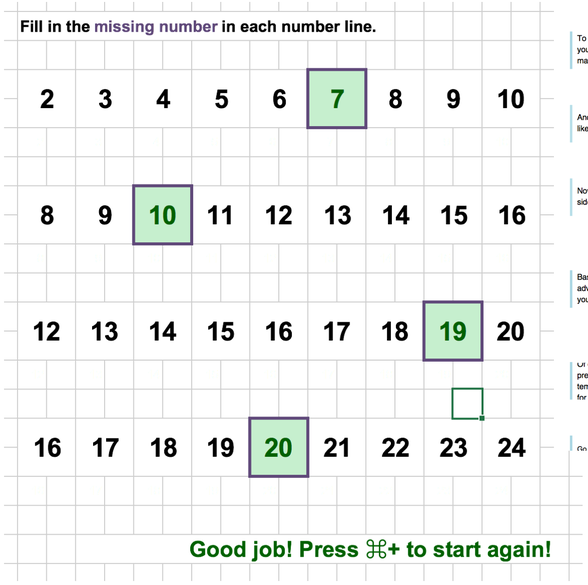
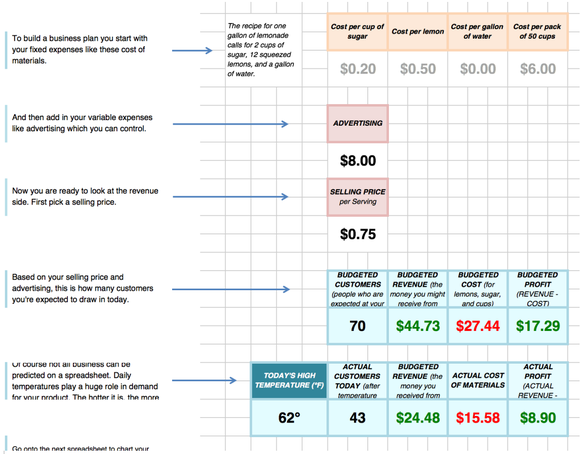
Although long term feedback is not directly fleshed out in the prototype, there still lies the opportunity to create a **meaningful and engaging feedback loop.** Game-ification of each lesson can be achieved where users feel a sense of progression and purpose. **An example** I've developed uses business simulation as a realtime interactive game to drive interest and encourage long term use of a spreadsheet – although the prototype has been design for short sessions.





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SPREADSHEET MATH

LEARNING GOAL

Options for Perception	**Options for Physical Action**	**Options for Recruiting Interest**
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Options for Comprehension	**Options for Executive Function**	**Options for Self Regulation**

Spreadsheet mathematics makes an explicit attempt to teach fundamental math concepts in a **cross-curricular manner** by utilizing business software and encouraging software and computer literacy. Not only does this support the learning of technology, but may provide a more accessible platform to an age of children more familiar with screen interactions rather than abstract thought processes.

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SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
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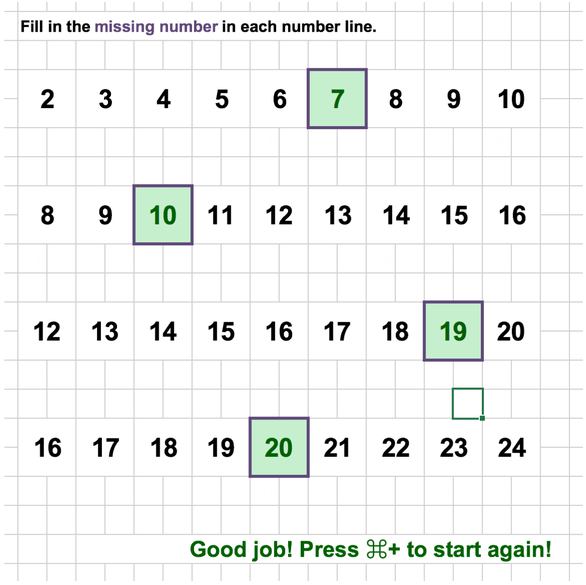
Options for Comprehension	**Options for Executive Function**	Options for Self Regulation

At the heart of providing options for executive function is **short-term, attainable goals**. Each lesson utilizes short, adaptable, and refreshable exercises that keep the user engaged – with built-in feedback that gives each user **motivational pushes** throughout their learning.



Short term goals

Long term goal

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SPREADSHEET MATH

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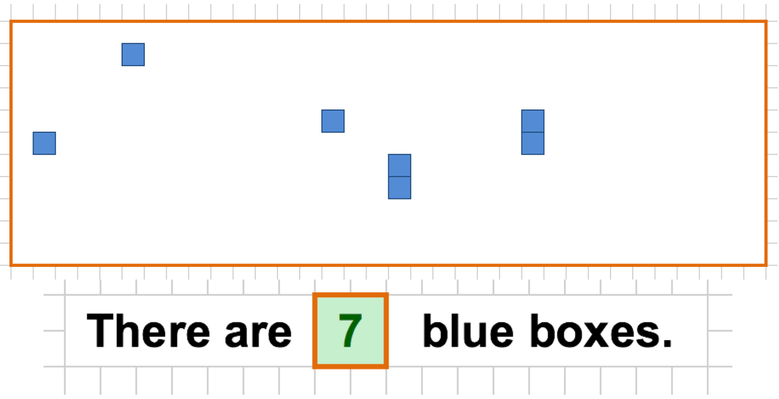
In providing options for self regulation, it is important to **expose users to certain phobias as they relate to their aptitude**. A common difficulty those with math-related LD have is being able to count large numbers of objects. By exposing them to this difficulty in a safe virtual environment, they can become comfortable in their ability and receive the extra help they require.

"Children with dyscalculia take longer than other children to count dot patterns. Most instantly recognize patterns of up to four dots, whereas dyscalculics tend to count the dots one by one."

(Callaway, 2013)



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LEARNING GOAL

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Goal for End User: To develop fundamental number sense and mathematical confidence using the interactivity of spreadsheet software.

Primary Persona: Alex – a 3rd grade student who regularly displays signs of math-related learning disabilities, including difficulty estimating, representing quantities with objects or visualizations, and dissecting word problems.

Learn more about research**, personas, and my** other work **involving Spreadsheet Curriculum.**

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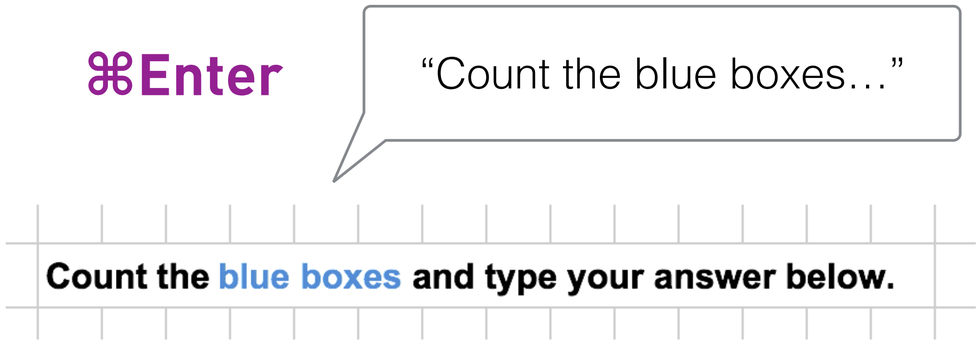
Also implemented into the prototype is a native **Text to Speech** functionality, which can be utilized with the simple keyboard command **⌘Enter**. Excel will read out loud the selected cell or a group of selected cells.



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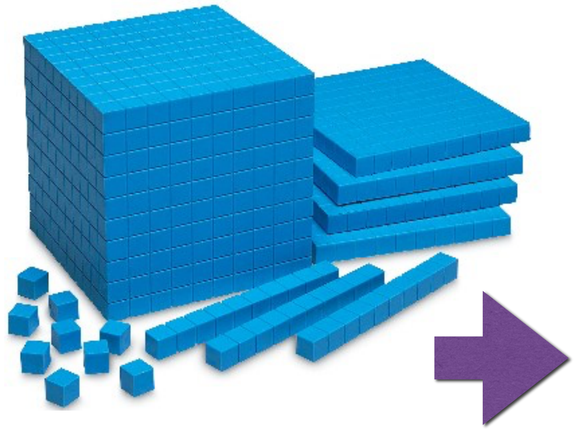
Spreadsheets can also be paired easily with such tangible class materials as 100s counting blocks – which provide a 1-to-1 physical representation of the material.

"Poor representational ability has been linked to poor word problem-solving performance for students with and without disabilities"

"Research consistently supports the idea that structured lessons on the use of visual representations can improve the problem-solving performance of students with LD"

(Gonsalves & Krawec, 2014)



23	+	5							
91	92	93	94	95	96	97	98	99	100
81	82	83	84	85	86	87	88	89	90
71	72	73	74	75	76	77	78	79	80
61	62	63	64	65	66	67	68	69	70
51	52	53	54	55	56	57	58	59	60
41	42	43	44	45	46	47	48	49	50
31	32	33	34	35	36	37	38	39	40
21	22	23	24	25	26	27	28	29	30
11	12	13	14	15	16	17	18	19	20
1	2	3	4	5	6	7	8	9	10

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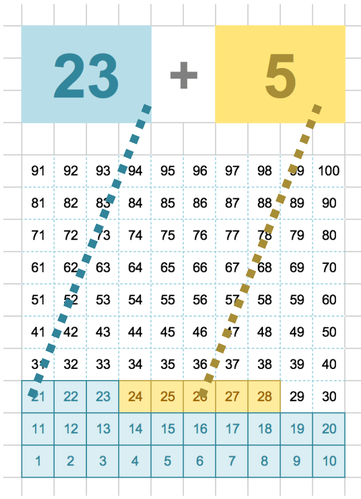
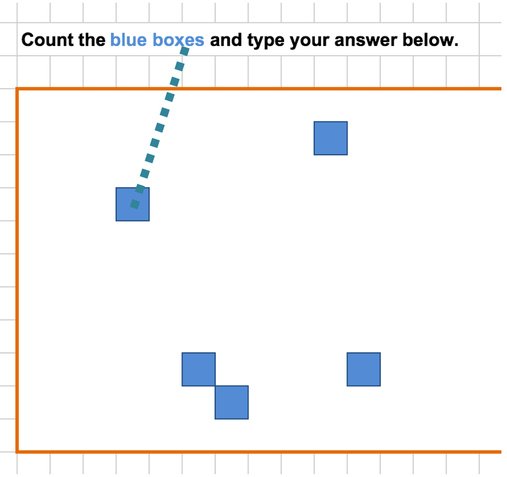
Each design decision in the visual treatment of each exercise is taken into consideration. In the Addition prototype, colors are not being used as decoration, but rather provide an important visual connection between character representation of a number, and its quantified object representation (blocks).

"...spatial representation [is] key to number sense."

"...even more fundamental to number sense... 'numerosity coding': the understanding that things have a precise quantity associated with them, and that adding or taking things away alters that quantity".

(Callaway, 2013)





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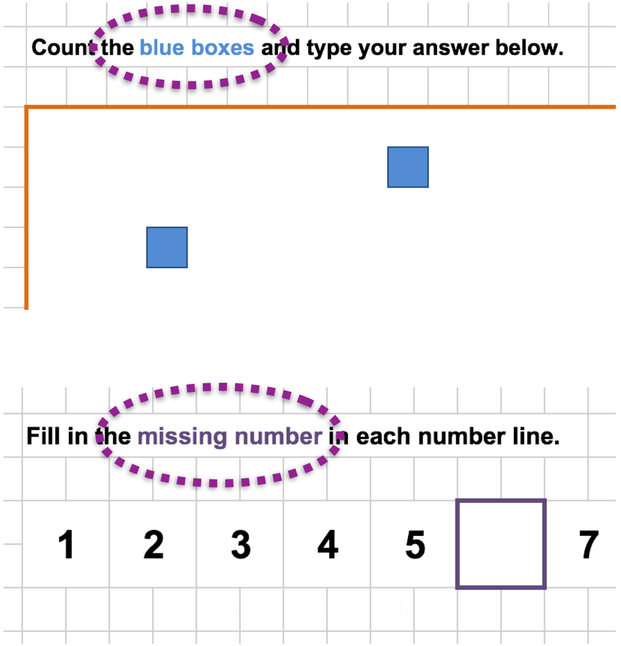
In addition to presenting numeric symbols clearly, written language is presented in an equally considered manner. Key words specific to the exercises are **set in contrasting colors** to not only emphasize their importance, but to also connect its meaning to another object on the page. Color is used as an organizing tool, and allows for the clear consumption of the material and limited distractions.



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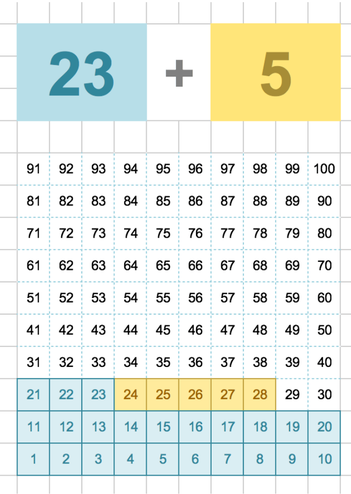
An aspect of providing options for comprehension is the idea of **highlighting patterns and relationships.** For example, in the addition prototype, you will notice that the page does not include an answer or asks for an answer. Instead, the interactive **highlights the relationship** between both numbers, the representation of the numbers, and the relationships between both numbers as a **sum.**



Numbers

Sum

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SPREADSHEET MATH

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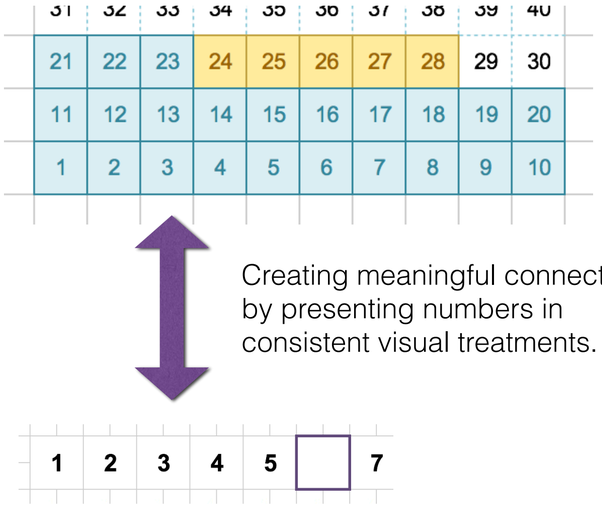
Spreadsheets allow for the organization of mathematical concepts into “boxes”. By creating grid surfaces to apply learning experiences on, users can make visually significant connections between problems to reinforce early number sense.

“Because early concepts of numerosity and the ability to sequence items according to quantity are related to visual-spatial capabilities, individuals with disorders in this area do not have a firm conceptual base on which to build operational and procedural skills in math.”

(Fleischner & Manheimer, 1997)



Creating meaningful connections by presenting numbers in consistent visual treatments.

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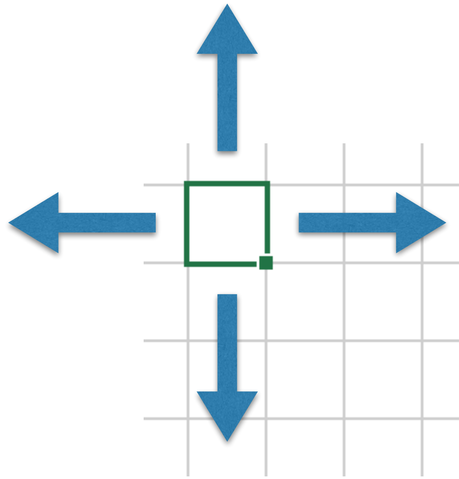
An advantage of spreadsheet software is its ability to be used entirely with a number pad (right). Although not utilized in today's demo, a user could **easily and efficiently navigate and input** answers using a number pad and arrow keys. This allows for one hand use, and does not require fine motor skills – allowing for accessibility in a physical realm.



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SPREADSHEET MATH

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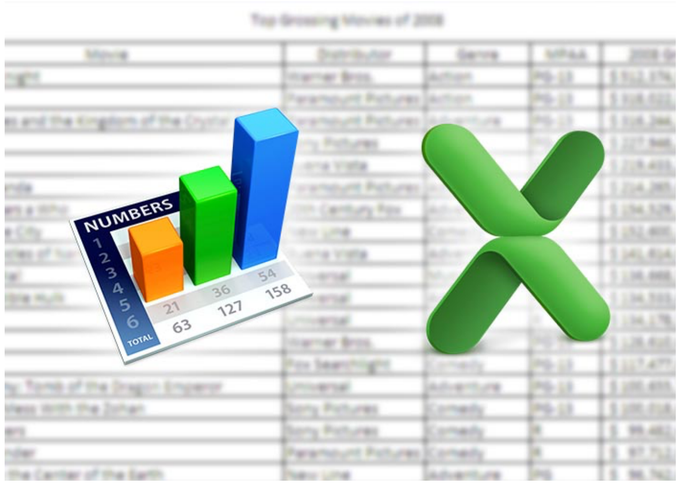
The decision to utilize common spreadsheet software as opposed to specialized proprietary software derives from their continued development by large companies dedicated to creating accessibility support. Within Excel and Numbers are native functionalities that work **with** the built-in accessibility options of each computer, **not against them.** This also means that students who already use assistive technology will have built-in support for these programs.



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SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
Options for Language	**Options for Expression**	Options for Sustaining Effort
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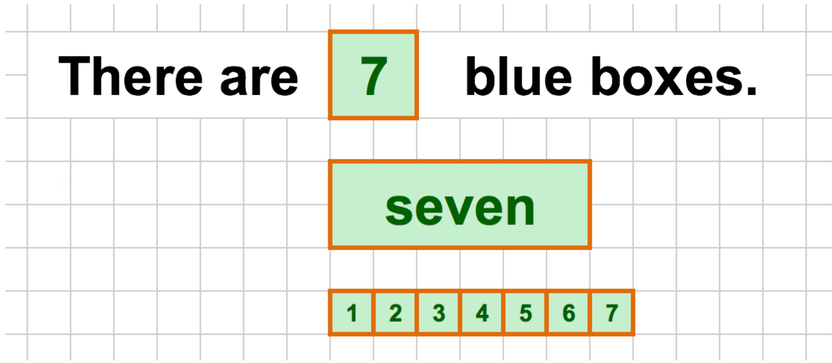
The scalable nature of spreadsheets allows for their content to be bent and manipulate for the individual's needs. Conditional formatting can require a user to type the word "seven" instead of the number to reinforce word associations.

"... some work shows that dyscalculics are poor at recognizing small numbers, suggesting that this ability is also fundamental to numeracy."

(Callaway, 2013)



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SPREADSHEET MATH

LEARNING GOAL

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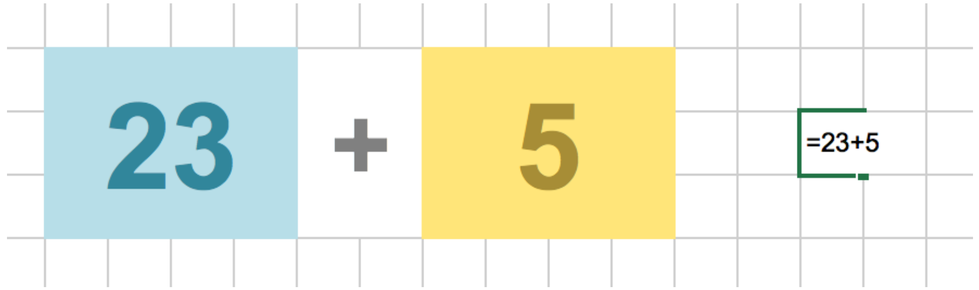
Spreadsheets are the virtual **multi-tool of mathematics.** In every cell lies a calculator, used by typing simple formulas. Cells and numbers change and interact with the user, providing them with visualizations and tools to support their learning experiences. Graphs, counting blocks, and word representations can be utilized in the same space to provide users and teachers with a playground to apply tools, rich content, and interactive curriculum.



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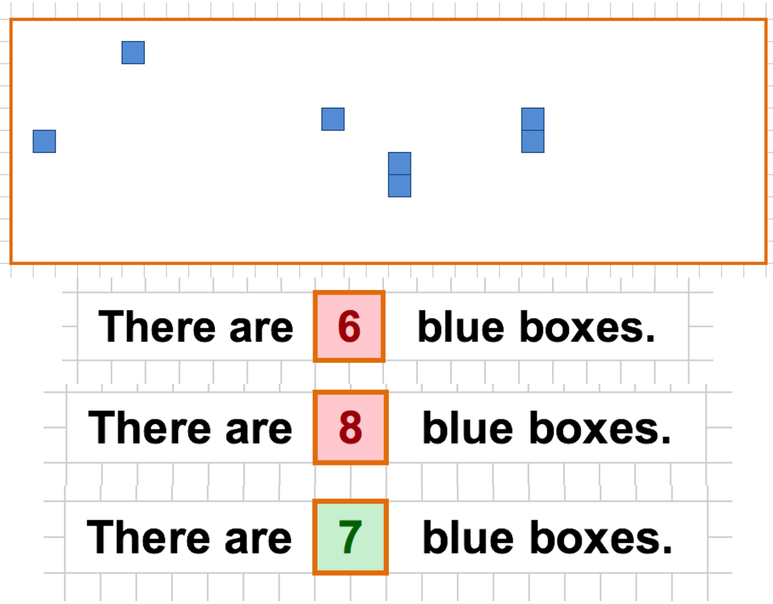
SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
Options for Language	Options for Expression	Options for Sustaining Effort
Options for Comprehension	**Options for Executive Function**	Options for Self Regulation

Supplying **built-in instant feedback** within the interactive exercises is essential for ensuring productive executive functions and maintaining engagement. Users can immediately monitor right and wrong answers – with an eventual implementation of more structures like counting correct answers or keeping scores to provide even greater sense of accomplishment.



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In more advanced applications – seen in my other work at **whatifmath.org**, the opportunity to develop a linked and organized syllabus within the spreadsheets can provide users with **assessments, checklists, and scoring rubrics** that can further enhance the learning environment within the software.

This example can be downloaded **here.**

	Topic	Objectives		Date		Lab	Question
		Spreadsheet	Math	Start	End		
1	Inputs, Outputs, Rules	Make and use rules, copy and paste	Make numberlines			Introducing Spreadsheets	How do spreadsheets work?
						Number Lines	How do you use a rule to make a numberline?
2	Addressing: Rows and Columns	Use cell addressing	Create and use variables			Addressing	How do you use a cell address to calculate?
						Rows and Columns	How would you make a rule to fill a column or a row?
3	Number Lines, Tables, & Patterns	Use relative and absolute addressing	Build numbersense with operations on numberlines			More Number Lines	What if you make a rule that subtracts?
						Number Patterns	What numberline patterns can you make with simple rules?
						Number Series	What numberline patterns can you make with other rules?
4	Addition/Subtraction Patterns	Make tables with multiple columns and rows	Patterns in addition & subtraction tables			Addition Patterns	How would you use a rule to build an addition table?
						Subtraction Tables	What patterns do you see in a subtraction table?
5	Addressing: Relative and Absolute	More relative and absolute addresses	Multiplication tables			Make a Hundreds Table	How would you use a rule to build a hundreds table?
						Build a Times Table	Can you build a times table with just one rule?
6	Multiplication/Division Patterns	Decimal Places	Division tables			Odd Times	How many odd products are in a 12*12 times table?
						Division and Ratio	What patterns do you see in a division table?
7	Factor Patterns	Using color to highlight cells	Factoring			Factor Table	How can you turn a times table into a factor table?
						The Magic Rectangle	Is their a pattern to every rectangle you draw on a times table?
8	Place Value	Building Models	Place Value			Place Value	Can you build a place value engine?
						Place Value Thousands	Can you make that model go to thousands?
9	Integers	Conditional Formatting	Integers			How Many Times	How dense is the times table?
						Multiplying Integers	What rule would extend a times table to negative numbers?
10	Exponents and Roots	Number of cells in a spreadsheet	Powers of 10 & 2			Powers of Ten	How would you show powers of 10 using a spreadsheet?
						The Chessboard	What would be a fair prize for inventing chess?
X	Course Project	Use rules to build tables	Numbersense--seeing the patterns in sequences			There are a variety of famous and not so famous number sequences like square numbers, triangular n patterns such as polygonal numbers and Catalan numbers. You can even create your own. For this pr	

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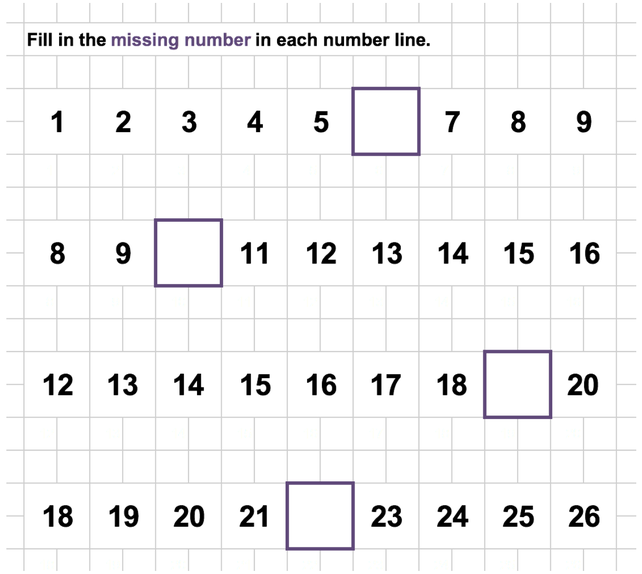
Each exercise is designed with a minimalist aesthetic, allowing for content to be comprehended without **any distractions.** The offline nature of the prototype isolates the user from otherwise distracting internet platforms – and its detachment from social learning and focus on individual growth provides a judge-free and self-propelled learning environment in addition to normal classroom learning.

"It may be the case that what these kids [children with mathematics-based LD) need is just much more practice than the rest of us (due to research that shows nurturing the roots of number sense may improve math success, rather than original research that places memory, attention, or language at the cause of math LD"

(Callaway, 2013)



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SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
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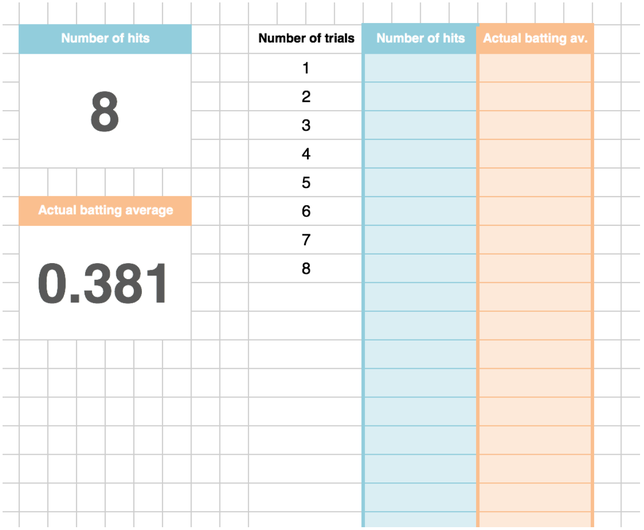
Spreadsheet curriculum has the distinct advantage of being quickly altered and customized to fit the interests of the user. In **this example** a spreadsheet lesson is built around the real-world data of baseball statistics. Although I have built my prototype for a universal audience and have not attached real world significance, it is easy to **tailor the content to fit the learning interests of the user.**



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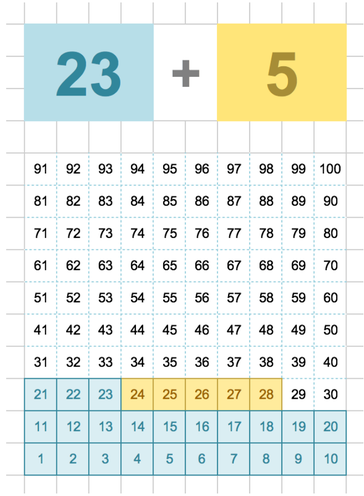
SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
Options for Language	Options for Expression	**Options for Sustaining Effort**
Options for Comprehension	Options for Executive Function	Options for Self Regulation

An example of sustaining effort lies in the addition prototype, which uses **substantive and informative feedback rather than comparative or competitive feedback.** In this example, the exercise becomes more of a tool, allowing users to use numbers (either drawn from a word problem, or based on real life examples) to understand relationships. Unlike a calculator, the student must understand how the two numbers work together to reach the sum.



BACK

SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
Options for Language	Options for Expression	**Options for Sustaining Effort**
Options for Comprehension	Options for Executive Function	Options for Self Regulation

Although not implemented into the current prototype build (there are limitations when using manual recalculation with ⌘+ that prevent many interactions) the spreadsheets are able to **create meaningful feedback** by "coaching" the user through activities using customized reminders, guidances, and scaffolds that can help the user reach his/her goal.

BACK

SPREADSHEET MATH

LEARNING GOAL

Options for Perception	Options for Physical Action	Options for Recruiting Interest
Options for Language	Options for Expression	Options for Sustaining Effort
Options for Comprehension	Options for Executive Function	Options for Self Regulation

Spreadsheet math curriculum has the unique advantage of being **driven entirely by the user's participation**. There are no on-screen prompts. There are no time-sensitive interactions. The user will only learn during times of engaged, focused learning. By emphasizing bi-directional learning, in which the user drives his/her learning through exploration and experimentation, users may feel in control of a subject they otherwise felt oppressed by.