Common Features of mathies Learning Tools

How do they support student learning?

Common Feature	Teaching Considerations	Cognitive Domains/Processes Made Explicit
Interactivity The elements provided by the tools are quick to create and easily moved, duplicated and manipulated.	When students do not need to worry about making accurate representations themselves, they can concentrate on the mathematical aspects of their work. Many students find working with virtual manipulatives more engaging than working with a limited set of physical manipulatives. Often students will persevere longer when using digital tools, trying different approaches as compared to when using pencil and paper. Depending on the materials available in the classroom, virtual manipulatives may be easier for a teacher to access and manage than physical manipulatives. Students benefit from access to an endless supply of configurable representations when they use virtual manipulatives. They benefit from more direct and kinesthetic interactions when using physical manipulatives.	**Perceptual Reasoning** Thinking, reasoning and conceptualizing are promoted through dynamic interactions with the mathies digital learning tools. **Visual-Motor Integration** Creating representations with mathies digital learning tools as opposed to by hand minimizes inaccuracy and frustration. **Executive Functioning** A digital environment provides the necessary tools to represent and communicate thinking without requiring the organization and management of a variety physical materials. The dynamic nature of mathies digital learning tools supports making and testing conjectures, providing immediate feedback for students. This promotes self-monitoring and strategic decision making. **Memory** Use of mathies digital learning tools supports the development of conceptual understanding, enabling storage in and retrieval from long-term memory.

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Settings Tools allow for various customizations by changing settings either from an opening dialog, workspace button or settings dialog. Changing a setting allows the student to exercise personal choice or make adjustments to meet a perceptual or other learning need.	Setting up the elements in the workspace of a mathies digital tool may involve some important instructional decisions. For example, the Fraction Strips tool and the Relational Rods tool allows the objects in the workspace to either show a numeric label or not. Showing the labels might reduce the cognitive load on a student but also might limit the sense-making needed for their conceptual development. Generally, labels might be more helpful once a student has had the introductory experiences necessary to ground their thinking.	**Processing Speed** Being able to resize or zoom in will help students focus on particular aspects of the representation.
Undo/Redo Undo is useful for correcting a faulty or unexpected action. Undo can also be used to return the tool to the start of a sequence of steps. Redo can then be used to review those steps or explain them to someone else.	**Observational Assessment** Being able to undo/redo encourages risk taking. A teacher can better assess student thinking by reviewing all the steps taken using a tool rather than by looking at a final static image.	**Executive Functioning** Undoing and redoing provides opportunities for students to engage in self-assessment. This may provoke refinements to their solution. **Memory** Undoing and redoing provides visual prompts which can trigger a student's memory of their math thinking. Pairing student think-alouds with this process can further support memory. **Perceptual Reasoning** Paying attention to student actions with tools can provide significant understanding of their math thinking, even if not accompanied by verbal or written language.

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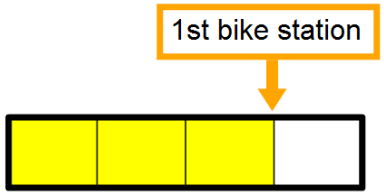
Annotation Freehand drawing, lines, shapes and text boxes can be added to the workspace.	The mathies digital learning tools are effective sites of problem solving for students. The annotation tools give students opportunities to support their reasoning by adding notes, explanations and wonderings. The annotation tools give students opportunities to communicate their thinking and support their conclusions.	**Working Memory** Using annotations as students work through a solution enables tracking of key information. *Example:*  **Visual-Motor Integration** Choosing the annotation text tool in lieu of the pencil tool can alleviate the challenge of visual-motor integration. When used on mobile devices, the built-in speech tool can be used in the text tool mode which provides additional support.

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Images Saved images can be added to the workspace  . Students can use the built-in screen capture capabilities of their device to save images of their work for assessment or for additional work.	An image of the problem that a student is working on can be imported right into the tool. Images of related objects can be imported and copied (e.g., images of household objects for the mathies Money tool)	**Memory** By importing an image of the task into the mathies tool's workspace, students can more easily refer to it. They are less likely to lose track of requisite information as they move back and forth between the task and the solution. Images can be further enhanced with annotations. *Example:* A student tracks each step of the problem as they work through it with a yellow highlight and underlines important parts of the text in red.