







to make the gate visible in the widget. From our observations, we believed that other participants would have the same preference. After participants triggered the radial menu, their first instinct was to use the stylus to target one specific gate and wait for response from the system. We also found one mode-switching issue. For instance, some users would unintentionally trigger the radial menu when trying to change the position of logic gates already present in the sketching area. We conjecture that using a mode inference approach [7] could reduce this ambiguity.

#### Expression User Widget

Four out of six participants found it easy to manipulate. However, one participant reported being frustrated by wrong recognition results when writing expressions. For example, when he wrote apostrophes as negation operators, they were always falsely recognized as another notation, requiring him to select an alternative recognition result. He recommended to use a hat symbol as the negation operator.

#### Truth Table User Widget

All of the participants appreciated not having to draw the entire truth table. One participant said, "I like how I could add variables easily with the menu at the bottom." Another participant commented that it would be better to initialize all of the output values to zero first and then scribble out non-zero values, replacing them with ones.

#### Feedback

All participants preferred our two approaches, as both of them provided intuitive ways to visualize and comprehend boolean functions.

Overall, every participant preferred having separate widgets, and one of them commented that it was a natural way to represent boolean functions. Another user commented "I did like LogicPad but I think you should be able to have the choice on if you want separate widgets or not." All participants who used LogicPad thought that it was a good verification tool for problem solving, but two commented that it would be better if LogicPad was faster and more reliable.

#### CONCLUSION AND FUTURE WORK

We have presented LogicPad, a pen-based tool that support boolean function visualization and verification. It provides different sketching areas to write boolean function representations and parses user's logic representations in order to generate other boolean function representations. In the logic gate diagram widget, we illustrated one mixed sketch-drag-and-drop approach. We also conducted an informal study, where we found that our boolean function knowledge representation approach was well liked by the participants. We also found that participants wanted tools to help them to verify their problem solving results in general. In the future, we plan to continue to explore under what circumstances should a sketching interface or drag-and-drop interface be chosen, how LogicPad could be used to aid students, and understanding LogicPad's pedagogical implications.

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