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### Software

The tablet is positioned vertically on a table in front of two learners, aged 9–10. The pair work together to solve a series of increasingly difficult ratio / proportion problems, ranging from comparing simple whole numbers to complex fractions. For each problem, they must size the left and right columns in proportion to their respective numerical labels.

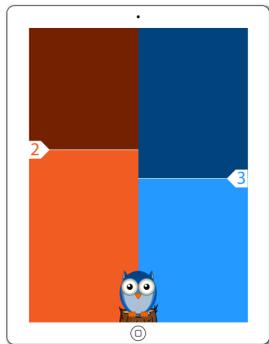
### Research

Each year, tablets become more affordable, capable and widespread. Inspired by work on interactive tabletops [2, 5], this research investigates how tablets can support co-located collaborative learning. It focuses on (1) how children use verbalization and gesture to collaborate and (2) issues of equity of collaboration [4] on the small interactive surface.

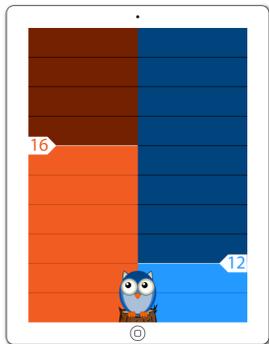
### References

- [1] D. Abrahamson and D. Trimic. Toward an embodied-interaction design framework for mathematical concepts. In *Proceedings of IDC '11*, pages 1–10, New York, 2011. ACM Press.
- [2] P. Dillenbourg and M. Evans. Interactive tabletops in education. *International Journal of Computer-Supported Collaborative Learning*, 6(4):491–514, 2011.
- [3] M. Kapur. Productive Failure. *Cognition and Instruction*, 26(3):379–424, 2008.
- [4] J. Rick, A. Harris, P. Marshall, R. Fleck, N. Yuill, and Y. Rogers. Children designing together on a multi-touch tabletop: An analysis of spatial orientation and user interactions. In *Proceedings of IDC '09*, pages 106–114, New York, 2009. ACM Press.
- [5] J. Rick, P. Marshall, and N. Yuill. Beyond one-size-fits-all: How interactive tabletops support collaborative learning. In *Proceedings of IDC '11*, pages 109–117, New York, 2011. ACM Press.

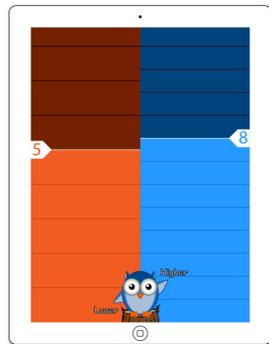
### Supporting Proportional Reasoning through Different Interfaces



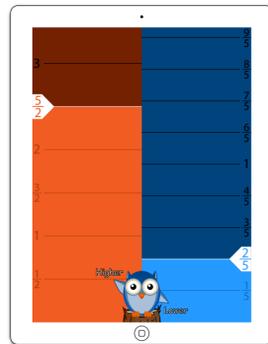
Without support, learners must estimate the ratios. Embodied proportional reasoning, relying on rules-of-thumb (larger denominator means smaller amount) and estimation, are particularly important for learners to relate their everyday experiences to mathematical concepts [1].



With a 10-position fixed grid, learners have precise places that they can target based on mathematically analysing the problem. Here, one strategy is to divide both numbers by a common factor (e.g., 4) and place them on the respective lines. Here, children placed them incorrectly based on the last digit.

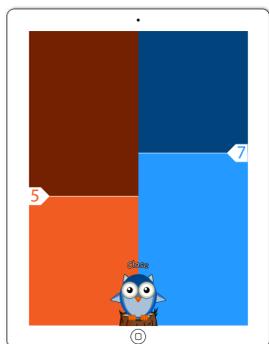


With relative lines that expand based on the position of the columns, learners can use counting to help them solve a problem (e.g.,  $8 - 5 = 3$ , so the 5 column should go 3 below the 8 column). They can also use a more embodied strategy such as aligning the grids of both sides to match.

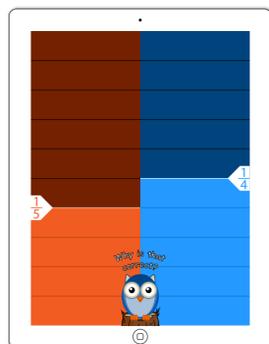
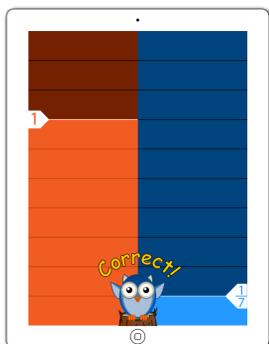


When relative lines are labeled, learners can use positions other than the respective column heights to line up the columns. For instance, in the case of fractions, a useful strategy is lining up the whole numbers. In this problem, the right column can be lowered until the 1 matches the 1 on the left column.

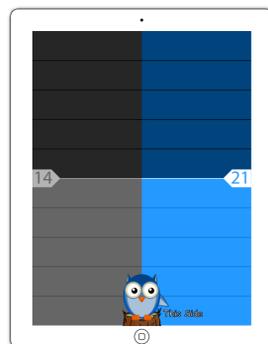
### Real-Time Feedback



Proportion provides two levels of real-time feedback. If the ratio of the column heights is within a certain tolerance of the correct answer, "close" is displayed. If it is within an even smaller zone, "correct" is displayed and learners move on to the next problem. The tolerances are based on both the support level (more tolerant for no support) and location in the problem sequence (more tolerant the first time a concept is introduced).



Verbalization is generally considered essential to collaboration, but is often replaced through gesture for interactive surfaces. Proportion uses two scripts to explicitly encourage verbalization. In **verbal reflection**, users are prompted to answer how they solved a problem that took them more than 30 seconds to solve. In **productive failure** [3], users are given a difficult problem at the beginning of a problem series and asked to solve it one side at a time.



# Proportion

A Tablet App for Collaborative Learning

