Visualizing Progressions for Education and Game Design

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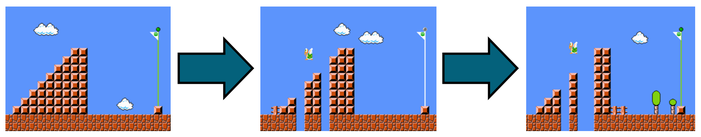
Introduction

A critical component of education or game design is crafting a coherent and effective sequence of content. We call this sequence of elements a **progression**. Each element (e.g., stage, problem, level, puzzle) covers a particular set of skills or concepts, which generally increase in difficulty over the progression.

$\frac{1}{2}+\frac{1}{2}$ ⇒ $\frac{1}{4}+\frac{1}{5}$ ⇒ $\frac{1}{8}+\frac{1}{13}$

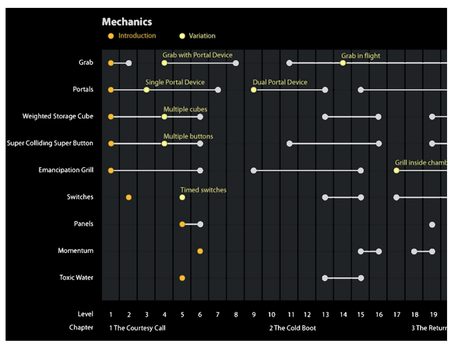


Example concepts: Adding unlike denominators, jumping over gaps in a platforming game.

Progression design is an iterative process, choosing which concepts appear when and how they are combined, then testing with students. Progressions for games and education are often hand-created, and our research group is also exploring generating progressions automatically. We need effective visualizations so we can quickly assess differences between progressions.

Design Challenges

We represent **progression plans** as a matrix describing how heavily a particular concept is used in a particular stage of the progression. That is, each stage is a high-dimensional vector of concept counts, which makes it both challenging to reason about and visualize.

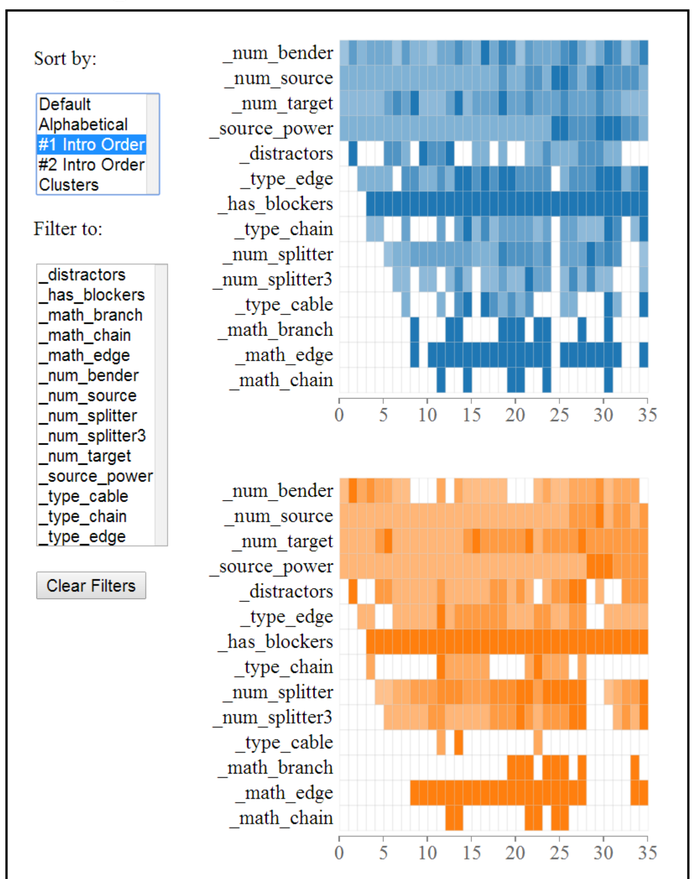


A subset of the progression plan for the game *Portal 2*.
Previous visualizations consist only of static tables, making certain queries difficult to answer.

Our system aims to allow designers to answer:

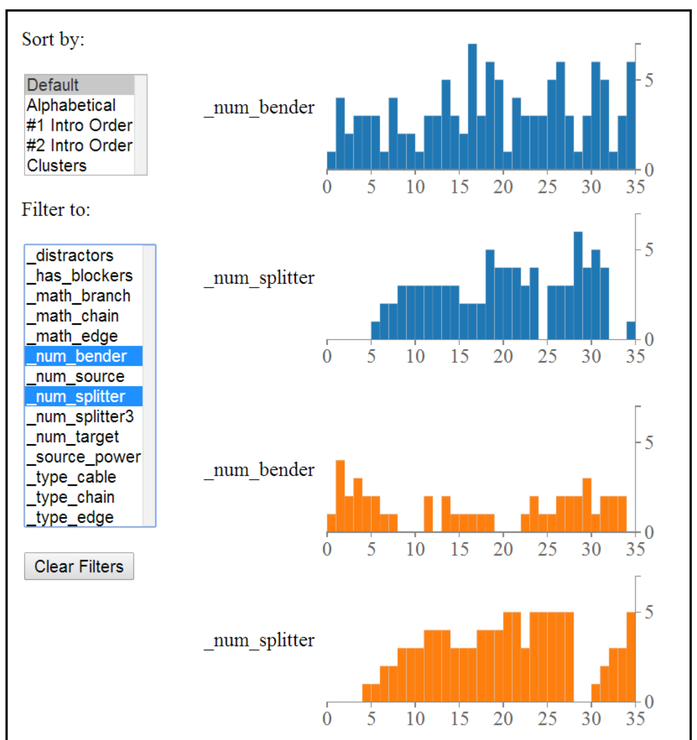
- In what order are concepts introduced?
- Which concepts are used in combination?
- How does complexity change during the progression?
- How do two progressions differ?

Sorting



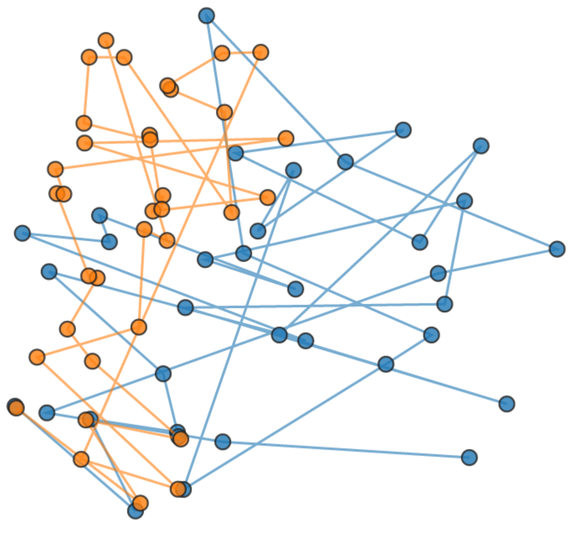
The application shows two progression plans as tables, with concepts as rows and stages as columns. Designers may sort the concepts by various criteria. Here, it is sorted by order of introduction of concepts in the top progression, making clear that the bottom progression has a different ordering.

Drill Down



Designers can drill down to view a particular set of concepts. Bar charts facilitate direct comparison of individual concepts.

Projecting into 2D



We use Multidimensional Scaling to project both progressions onto a 2D plane. This view helps identify areas of the "design space" that are covered by one progression, but not the other. Details-on-demand and brushing-and-linking allow designers to identify particular stages.

Approach

Our system is an interactive visualization that directly compares two progressions. These examples show two progressions for *Refraction*, an educational game about fractions, developed by the Center for Game Science. We often make different progressions for different audiences; here, the first (**blue**) progression is for a general audience, the second (**orange**) is for younger children.

An example puzzle of *Refraction* and the concepts associated with it. The concepts describe mathematical and spatial challenges in the puzzle. For example, this puzzle has "_num_bender" = 1 and "_num_splitter" = 2.

Future Work

- Explore other unsupervised techniques such as clustering and dimensionality reduction on the set of concepts.
- Integrate player data, e.g., showing player retention rates or the average time players take to complete each puzzle.
- Display metrics and measures of progression differences, e.g., edit distance, subsequence alignment.