Alice in Arealand

Alice in Arealand focuses on teaching and assessing geometric measurement, specifically the development of a deep understanding of the concept of area. The key challenge for the game is to simultaneously (a) be engaging, (b) scaffold students through a research-based learning progression, and (c) gather evidence for the creation of assessment models that indicate whether students have mastered the stages of that progression.

Seed

Tell us about your idea or project. What's your vision?

While recent years have seen the development of excellent games for learning, very often these games are isolated from the rest of classroom activity. Even if a teacher draws on references to the game in a lesson, it is often unclear how the lessons of game play fit into the rest of the curriculum. Certainly data from students' game play is rarely integrated with data from other student work to inform us about mastery of skills and knowledge.

Alice in Arealand is meant to be one piece of an integrated system of learning and assessment. The activities in the system are theoretically integrated through a common learning progression. This framework that lays out the major stages in the development of the skill will be carried across the game, other digital performance tasks, and in-person classroom activities. The activities will then be quantitatively integrated through data collected from each and aggregated together, leading to estimates of student mastery at each stage of the progression.

What problem are you trying to solve and why does it matter?

Alice in Arealand focuses on teaching and assessing geometric measurement, specifically the understanding of area. Many curricula and classes still focus on teaching the formula area = length x width. However, students miss the significance of what the resulting number indicates, namely the number of square units that can fill the space. New common core math standards emphasize the understanding of area, not just the rote calculation of the formula, but few resources exist with which to teach and reinforce these concepts.

The game specifically targets three main stages in the development of area.

1. Area Unit Iteration—This stage emphasizes the understanding that a space can be filled with smaller unit squares placed end-to-end in non-overlapping fashion
2. Use of Unit Squares to Measure Area—In this stage, learners perceive 2D shapes as collections of single area units and use those units to reason about area. Area would typically be computed by counting the number of squares in the area.
3. Use of Composites to Measure Area—Learners perceive 2D shapes as collections of area composites and use two-level composites to reason about area. For example, a learner would combine the single squares into rows or columns, and then determining the number of rows or columns needed.

The key challenge for the game is to simultaneously (a) be engaging, (b) scaffold students through the above progression, and (c) gather evidence for the creation of assessment models that indicate whether students have mastered the stages of the progression.

Tell us about the team you have assembled or hope to assemble.

The team was brought together with the understanding that a multidisciplinary approach was crucial to addressing our challenge. The team includes:

- Experts in the application of Evidence-Centered Design in assessment (particularly the identification and aggregation of evidence from digital environments) from Pearson
- Math education experts who have been involved in the creation of both math curricula and formative assessments from Pearson
- Veteran videogame experts with combined 40+ years of game design experience from GlassLab and Crowell Interactive

The collaboration of these three different approaches would be key to the project and requires substantial work in developing a common language and common conceptions. The process of design of a game that is both a learning and assessment tool requires much push and pull from the three perspectives to deliver on the three pillars of Engagement, Learning, and Assessment

Sprout

Tell us about your process and how your idea is evolving throughout the project.

In general, the project followed an Evidence Centered game Design process (ECgD; Mislevy et al., 2014). ECgD seeks to combine the assessment argument development process of ECD with agile development methods common in game development.

Development began with a focus on the concepts to be addressed. With a solid grounding in the stages of the progression, initial tasks were developed in which game mechanics were aligned to the major concepts of each stage. Iterations of development included:

- A first iteration of paper prototypes was tested with a group of learners in an informal environment
- A second round of individual play testing conducted in a usability lab
- A third round of testing was conducted in three classrooms, and
- A fourth round of testing was conducted in six classrooms.

The early rounds focused on ensuring that ideas being generated were engaging for learners and also required use of the desired skills. The latter was accomplished through use of think-aloud protocols, which were monitored for both mathematical reasoning and evidence of engagement.

From an engagement perspective, in the early rounds we had to gain understanding of exactly what the curriculum was going to be, and where it fit into the larger arc of mathematics. The game designers approached the problem as they would a media based brand such as Indiana Jones or NASCAR, with constraints particular to such. In the case of Indiana Jones for example, clearly there would need to be fisticuffs and puzzle solving. In the case of the geometry curriculum, we would need to have students work with geometric shapes. No fisticuffs, but definitely puzzles. Then we needed to develop a progression of interactions that would match the learning progression and ask the students to exercise their understanding of those concepts.

Once we had some sense of the kinds of activities, we thought about how to wrap that learning progression inside a narrative that gave meaning to the activities. Using narrative to engage learners is a tactic as old as Aesop. At first, we planned to have the player imagine themselves to be present in the world, taking part in the adventure much as a reader of a storybook feels immersed in the imaginary world.

What are some of your initial concepts or designs? We'd love to see them.

Initial designs began with tangrams, given that the main component of the tangram task is to decompose shapes into component parts. We found the concept of Tangrams to be a great storytelling device that required the player to think in terms of geometric shapes (Figure 1). Each Tangram would be the solution to some situation that blocked game progress, so the player would be rewarded by being clever, creating interesting constructions, and unlocking the next area of gameplay. We also hoped to change the way the players viewed the world around them, seeing geometry at work in the real world objects all around them.

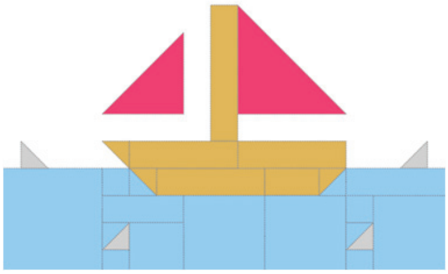

Figure 1: Storied Tangrams

In order to bring in additional stages, we also started to develop the idea of an economy of shapes. Players began with a set inventory of larger shapes and then could “trade” for smaller shapes by stating the correct number of smaller shapes they should receive. So, a player could trade in a 3x3 square for individual square units by indicating they should get 9 1x1 squares in return.

Figure 2: Economy of shapes

Have your initial concepts/designs changed? Why have they changed? Show us how they’re being refined and iterated.

We tested this initial idea with a paper prototype (created by cutting a LOT of shapes!). In listening to students and the facilitator, it became clear that the concepts we were targeting were most apparent when the facilitator was working with the player to conduct a trade. While the composition and decomposition of the shape was engaging, it was not eliciting the concepts of area units and composition with square units that the trading encouraged.

We discussed examples of stories that had solving puzzles at their core. Doctor Doolittle and Alice in Wonderland were two models that came up repeatedly. We decided to combine the best parts of both of those, with a pinch of Wizard of Oz thrown in.

The world was designed to be a flat 2D universe, with the built in limits of such. The inhabitants of that world would be bound to a flat plane, but our player, being from a 3D world, could view their world and take actions that the flat folk could not. This concept bestowed “super powers” on our players, who could use their knowledge of Geometry to solve the flat world’s problems.

The choice of Alice as the protagonist was based on our desire to give the student someone they could relate to, and to create a sense of “helping a friend”. This would hopefully inspire them to pay closer attention and think harder about solving the challenges that blocked their friend’s progress. Help that only they, as smart people from a 3D world, could deliver.

We knew we would need to allow players to perform transformative actions such as gluing pieces to together to construct larger compound shapes. We wanted to keep the fantastical nature of the world, and so created living creatures called “Goggles” (for their goggle eyes). Each Goggle has a personality, and does one kind of Action (Figure 3).

- Gluumi was a sad blob who could glue shapes together
- Esploda was an excitable bundle of dynamite who blew compound shapes back into single units.

- Multy came along later, as a nerdy multiplication symbol who made copies of shapes.

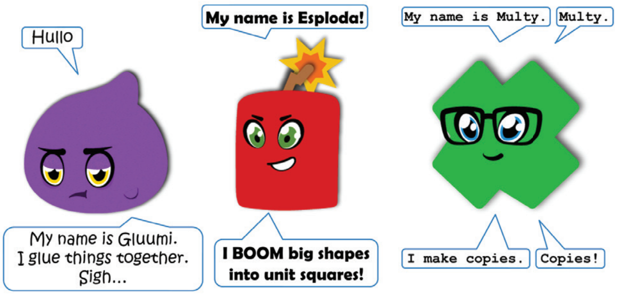

Figure 3: The Goggles

And finally, we added Flat Cat as a kind of Cheshire Cat companion for Alice. We needed to have another voice in the game to give feedback to the player, and to help push the story. His role turned into (like R2D2 or Alfred the butler) the humorous sidekick to Alice's straight man, who also knows more than he is saying.

Next began work on detailed design where the push and pull between learning, assessment, and engagement demands can become difficult. A key insight for the game designer was that focusing solutions on using the targeted concepts is important, as learning the concept is the goal, not simply completing the challenge in any way possible.

The mechanism developed to get from the idea of combining individual square units to combining rows and columns was the Goggle Multy. Multy makes copies of the shape indicated by a player. The idea is that a less-advanced player would use Multy to make copies of individual squares and combine them while a more-advanced player would combine a few individual squares into a row or column and then copy that. In this way, evidence, which requires observing player choice, could be gathered from game play actions.

Play testing revealed that, from an evidence perspective, this worked. 48 students played the level depicted below. 8 of them combined the four squares and then multiplied them twice, indicating understanding of using composites to reason about area. 21 players made eight individual copies and then combined the individual squares. The remainder did a combination of these approaches (which we might interpret as behavior indicating they were beginning to develop the concept of composites for area but had not mastered it yet).

However, it was not clear that players understood they could use Multy on combination shapes. It was possible our evidence was not indicating a lack of math reasoning, but a lack of game play skill. In addition, we were not just interested in creating an assessment, but also a learning environment.

Figure 5: Multy's appearance

We began discussing how to add a level prior to this level to support the use of Multy on combinations (the first level where Multy appears only required a 1x4 construction) (Figure 5). The team discussed creating a level where Multy was not available for use until a row or column was constructed, then only limited uses of Multy would be available, requiring only the correct number of rows or columns were copied. In addition, the characters for combining and breaking apart would be disabled.

This seemed like a good solution for leading the player to the understanding of the Multy solution aligned to using composites for area and the most efficient solution. However, on further reflection, the game designers realized that without any choice, the game is really not much different than watching a tutorial. The assessment designers realized that without choice there was no evidence to gather. The realization that both approaches had led to the same conclusion was an important moment in the collaboration. From here, the team began revision of the scaffolding of use of Multy.

What interesting patterns or insights have you discovered?

The game consists of a series of small challenges. Over the course of development, we came to a three step pattern for these challenges, as follows:

1. Introduce the new concept in an easy to way in the first level
2. Present a new challenge with some nuance that requires student to use the concept creatively and effectively in the next level
3. Add an additional challenge that requires more mastery of conceptual and direct use of the concept, often adding in complexity via earlier concepts to be used in combination in a third level.

The interaction and design process described in the previous sections is crucial to understanding how games that are learning and assessment tools must be developed. Interestingly, the game and assessment views were often in parallel. Choice is a key component to design and to gathering evidence. Assessment designers want choice that is related to the construct while game designers would not ordinarily be constrained in that way. In the above interaction, initial design gathered good evidence, but the inference from that evidence was not clear because game play and learning was not sufficiently scaffolded. In the search for better support, both the assessment and game designers reached the same conclusion about an overly-constrained solution from the separate perspectives.

After months of work and collaboration, the learning, assessment, and game experts can make suggestions and work out the challenges in a shared language. This representation of all three components has been crucial. It is sometimes tempting for education people to think they can make a game without an experienced game designer or technologists to think they can make a game without content experts. Both groups often fail to consider the creation of assessment models. In the end, all this leads to games that will not ultimately serve the three purposes of Engagement, Learning, and Assessment in a coordinated experience.

References

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