Feedback Loops in Games and Learning

Using game-design principles to shorten feedback loops in digital curricula.
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Muzzy Lane has been a pioneer in the application of game-design principles for learning, and in the development of educational games and technology. We believe that game-mechanics are among the most powerful tools available in the design of digital curriculum and learning experiences. One area where games excel is in providing players with useful feedback during an activity, so that players can adapt and improve their work. We call this process a feedback loop, and in this paper we will talk about how a game-inspired approach to feedback can be integrated in learning, and why we think it is important.

The term “feedback loop” originated in the design of control systems, and referred to the section of a system that provided feedback and allowed the system to self-correct - to adjust its operation by looking at the difference between actual and desired results.

Feedback loops have long been a core concept in game design: It is through feedback loops that players can learn from results (including “failure”) and improve performance. For example, in the popular game *Angry Birds*, players launch “birds” via slingshot, and by seeing where the birds land, learn to better understand (and adjust) trajectories. In more complex games, players can refine strategies through feedback loops. In our *Making History* strategy game, a player playing as England might try to provide troops to aid France, and through initial failure learn what time and resource are required, and plan differently for a second try.

Feedback loops also let the game itself learn and adapt the challenges that it presents to players. When a player shows she can consistently master a game-level, the game can make changes to increase the difficulty and add new challenges.

Feedback loops in learning

Feedback loops are also, interestingly, an important part of any learning process. In a feedback loop between a teacher and student, for example, a student performs work and a teacher periodically assesses the student’s performance, and hopefully adjusts the course of instruction accordingly. As a learner demonstrates mastery of a concept, her teacher can build on that understanding to present further concepts and move ahead. Alternately, the teacher can provide review materials to help improve the learner’s understanding of the concept.

This, of course, is a description of a one-to-one student-teacher interaction. In the real world, teachers usually have many students to work with, which means that assessing work takes time, and is therefore might only be done several times a semester. In addition, the

assessments may be focused on overall course performance, and though this lets teachers address groups of learners who are struggling in general, it doesn't help them give students specific, helpful feedback on the areas where they are having the most difficulty.

Applying game-feedback principles

In recent years, education researchers and practitioners have been looking at game design principles, and how they can be valuable in creating more effective instructional models, both in schools and in online digital curriculums. Leaders in this area have included Chris Dede at Harvard, Eric Klopfer at MIT, Kurt Squire at University of Wisconsin, James Gee at University of Arizona, and others. Muzzy Lane has been a pioneering practitioner in this area, both in learning-game design and technologies. One area we have focused on is the development of different types of game mechanics to support specific kinds of learning objectives.

We believe that game-based feedback systems have especially strong potential, and in our designs we emphasize providing two kinds of feedback: In-context feedback for students and performance-assessment feedback for teachers and assessment systems.

1. In-context feedback for students

Successful learning-game designs show players how they are doing in the moment. Players must be able to see the consequences of their actions, so they can adjust their actions and strategies in order to succeed. The types of feedback used can vary based on the learning objectives and game-mechanics. In a physics simulation game, a student might see results in terms of distance travelled after setting velocity and analyzing friction. In a historical role-playing game, students gather evidence, then take action based on their analysis of the evidence, and see results within the historical game world.

In both cases, the students get multiple chances to approach and retry a problem, to analyze their results and try different approaches. As they are immersed in a challenge, short feedback loops give them more practice and more experience with the problem.

2. Performance-assessment feedback for teachers

The second type of feedback is useful for teachers, and drives assessment and adaptive curriculum systems. Our goal is to provide a concise set of performance indicators that will let teachers quickly see where a student is achieving mastery, and where they may need help. This data can also feed assessment systems to automatically suggest support material that will address weak areas, or provide appropriate new challenges. These performance indicators can be used by teachers to decide where to intervene and provide help, and also by adaptive systems to determine what support or new challenge to direct a student to next.

Performance indicators are created with calculations that combine several pieces of data. For example, in a simulation game to teach marketing, one indicator might use the ratio between

media spending and awareness to show the student's efficiency in raising awareness among a target market (and their understanding of media planning and targeting). The indicators can also direct teachers to the more detailed data that lies behind them.

Technology to support these approaches

To support the application of game-based feedback approaches in digital curriculum, Muzzy Lane has developed technology in several key areas, including:

Flexible data models: Different topics and learning objectives require different game-mechanics to support them, and these mechanics produce different types of data. We've recognized that there is not a one-size-fits all scheme to describe all of the possible data that could be passed out of games to be assessed, so we've created a flexible data model to allow games to adapt and assessment engines to pull out whatever data is most useful.

Modifying individual game units by passing in data: We've designed our game systems to be parameterizable, making it possible to pass in data modifying their behavior. This data can be driven by analysis of assessment data, or by teacher controls. Modifications can include actual content used in a game unit, the difficulty level of the challenge, or new feedback for the student.

Small game units that can be stitched together: Commercial games (and many educational games) are large, unified "walled gardens." In contrast, we have focused on designing systems that create a larger experience by piecing together many smaller experience-units, This makes it possible for teachers or assessment systems to control the flow through a game, directing students to specific units, or looping back to re-do experiences where appropriate.

Conclusions and continuing work

The immersive and motivating power of games is built on their ability to provide players with immediate feedback on their success. Players (or students) can try a strategy, see problems, and make corrections to reach goals – all in the context of the immediate challenge. Students can practice more, apply more, and gain more experience.

Since students are spending more time with the material, they are also producing more useful data about the details of their interactions. Our flexible data systems can capture that data, and with it give teachers and assessment systems the power to provide specific and useful materials and direction to students. Building on the design and technology work we have done in this area, we are designing learning-game mechanics with assessment and adaptive goals in mind. With their ability to engage students and provide rich data to power adaptive assessment systems, we believe this work will be integral for future of digital education.

