6 Beetles, Beasties, and Bunnies in Your Back Pocket

As a single footstep will not make a path on the earth, so a single thought will not make a pathway in the mind. To make a deep physical path, we walk again and again. To make a deep mental path, we must think over and over the kind of thoughts we wish to dominate our lives.

—Wilferd Arlan Peterson

Many of the games presented so far are long-form, immersive games, in which players become deeply involved in the game play during a given session. Yet, resonant games can also take the shape of short-form, casual games, commanding players' attention for shorter periods but drawing them in more frequently, thus becoming part of the fabric of their lives in a different way. The events and places that become meaningful in our lives emerge in various ways. Many of us have special memories of a summer camp or vacation home that we visited regularly as children, perhaps spending a fun-filled week, or month, each year. It's plain to see why those intensive experiences create so many memories. Then there are places that at first glance seem less formative but are integral parts of our lives as well—the coffee shop we visit every week or the park we walk through on our way to work. While there may be fewer eventful moments in these places, the frequency of our visits makes them memorable parts of our lives, and later on, we may look back on them as fondly as the vacation destination. That repeated walking over the path creates a deep impression in us. Similarly, games can be integrated into our lives and implanted in our memories in these two different ways. Students who play *Radix* for full class periods during their evolution unit may look back at the end of the year and remember the triumph of finding that long-haired menji because they spent concentrated time immersed in the game world. But students who play *Beetle*

Breeders ten minutes at a time, at various times of day throughout their genetics unit, will be just as likely to look back at the end of the year and remember all the times they bred the right traits in just one generation—precisely because the experience was not concentrated but rather repeated and spread out across many moments of the students' lives. We see this play style in numerous commercial games—players remember senior year as the year they played *FarmVille* obsessively with their friends; or they immediately associate *Candy Crush* with their first job because it was their go-to game on the subway commute. The experiences discussed in this chapter belong to this game genre: mobile, casual games that can fit into players' lives in various ways. These "ubiquitous games" have many design elements in common with other resonant games, but they also have some special considerations worth examining.

Ubiquitous games, or ubiq games as we call them, are so named because they can be played anytime and anywhere. They are designed as mobile games, with a casual game-play style and a focused content area for learning, which provides a number of affordances.

- Ubiq games can be *easily accessed on a personal device* such as a smartphone. For many learners, this is a device they have with them all the time, and it's a device they often have in their hands. This increases the ease and likelihood of opening up a game for a quick round of play.
- Ubiq games can be *played in short, frequent bursts* because they have game mechanics that consist of rounds, challenges, or some interaction that can be completed in a short time frame, perhaps five to ten minutes. These interactions are strung together to become part of a larger experience of exploring a concept or system, but each one is finite and provides easy stopping points. This means they will be exposed to the concepts in the game more frequently, with continuous reinforcement.
- Ubiq games are designed to fit into the *interstitial moments of the day*, in terms of both game design and technology. Players need to have individual accounts that save progress constantly. This enables them to put down the game when they need to, and to pick it up again when they have the chance. Unlike a game they might play in the computer lab for hour-long sessions, learners end up playing ubiq games while they're waiting in line, on the bus, or at home watching their younger siblings. This makes it more likely that they will actually spend time with the game.

• Ubiq games can be *integrated into a curriculum* with increasing ease, as more and more students have access to their own devices, even if each student has a different device. Rather than taking up class time or teachers having to book the computer lab, playing ubiq games outside class time is more accessible and feasible than many other resonant games.

The UbiqBio Project

Ubiquitous Games for Biology (UbiqBio) was a project funded by the NIH from 2009 to 2011 that involved the design, development, implementation, and research of a suite of four games integrated into a high school intro biology curriculum.

We first worked closely with biology teacher consultants to design and pilot the games. Each of the four UbiqBio games covered specific standards-aligned curriculum points in the areas of Mendelian genetics, mRNA and translation, evolution, and food webs. The teacher consultants played a large role in identifying these as areas with which students often struggled. Each game also had a unique game mechanic, premise, and visual style, resulting in a diverse suite of games that balanced cooperative and competitive play, realistic and fantastical worlds, and simulation- and narrative-based games. Along with the games, a teacher dashboard was developed to collect game-play data relevant to each game's mechanics and content, which were displayed for teachers. Together with our teacher consultants, we then created supporting curriculum to help facilitate transfer and to make the games more accessible to other teachers.

The next phase was to work with a group of Boston-area high school teachers to implement the games in their classrooms. During each relevant curricular unit in the semester, teachers introduced the UbiqBio game in class and loaned their students Android smartphones provided by MIT. Teachers chose to assign the game either before, during, or after teaching the unit, as homework (or in some cases for extra credit), and students played outside class over the course of the approximately week-long unit. Researchers collected various data with the goals of learning more about (1) the efficacy, engagement, and feasibility of the UbiqBio games and approach; and (2) what types of casual games would best engage, motivate, and teach students. Throughout the course of this project, multiple design principles emerged that have informed our thinking on not only the ubiq

games genre, but also what we now think of as resonant games. These are the primary design principles presented in this chapter:

- Designing adaptive experiences
- Codesigning with educators
- Integrating into everyday life
- Connecting data to practice

To help readers become more familiar with the idea of a ubiquitous game, we start by describing the four games that were developed as part of the UbiqBio project. An overview of each game is presented here with some discussion of the most interesting features of each. Then we provide additional examples of other games, both from within the Education Arcade and from outside designers, that highlight key ubiq game design principles.

Beetle Breeders: Mendelian Genetics

> Premise: Customers want to buy beetles with certain traits, and it's the players' job to breed them. Players choose the contracts they want to work on, then mate the right beetles to produce the desired offspring. They use their knowledge of Mendelian genetics to work with increasingly difficult patterns of inheritance and to maximize profits!

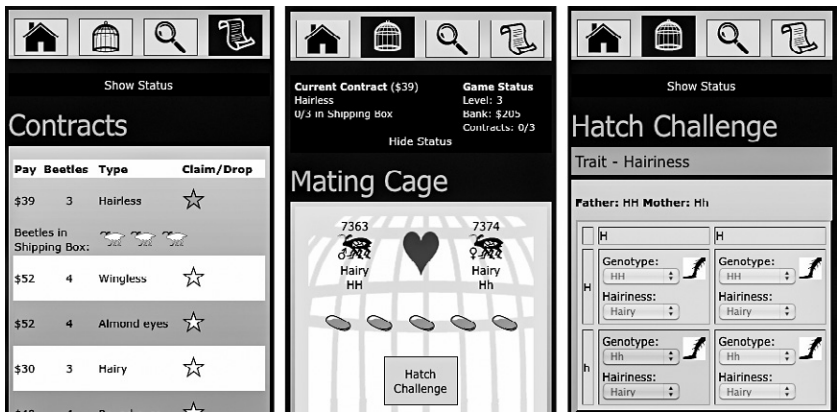

Figure 6.1
Beetle Breeders screen shots

Beetle Breeders facilitates learning for students by allowing them to play through just one or two contracts per session, and still get the experience of trying different crosses and seeing the results right away. One thing that sets the *Beetle Breeders* game apart from the others in this series is the richness of the biology content. A basic Punnett square mechanic lets students experiment with a wide variety of inheritance patterns, which makes it relevant to a larger chunk of the genetics unit (figure 6.1). Players work their way up through the levels of the game, encountering more complex tasks as they go. This keeps the game interesting and makes it easy to see their progress as they move through the curriculum.

Invasion of the Beasties: mRNA & Translation

> Premise: Strange and scary monsters are taking over! Players must genetically engineer their own band of monsters suited to fight each opponent. They use the Universal Monster Genetic Code to research which proteins need to be synthesized. They adjust the nucleotides in the RNA strands and match the correct amino acids to create polypeptide chains without mutations. If players are successful, the resulting phenotype will give their monster the ability to defeat the enemies!

The biology content of *Invasion of the Beasties* is more specific, focusing on the concept of the universal genetic code and the relationships among nucleotides, amino acids, and phenotypes (figure 6.2). There are three levels of increasing difficulty, but since the game covers fewer biology concepts, "beating the game" feels more attainable. More than our other games, this one is very narrative based and character driven. The illustrations bring the game to life, and players enjoy giving each other tips on how to solve the puzzle of which phenotype will defeat each enemy. The models of biological systems (such as amino acids, the universal genetic code, and genetic engineering) focus on how DNA and proteins work conceptually, rather

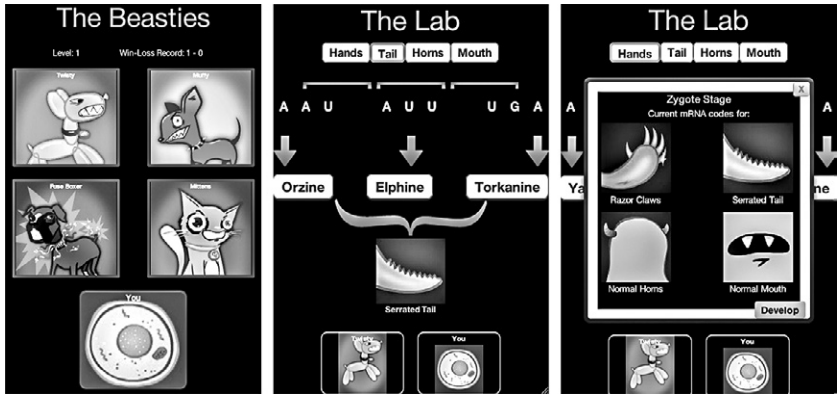

Figure 6.2
Invasion of the Beasties screen shots

than promoting memorization. These models are highly simplified, requiring teachers to highlight and explain the differences between the game and real biology, but also making the content more accessible and fun for students.

Island Hoppers: Evolution

> Premise: In a world full of islands, each with its own bunny population, small changes to the environment can have noticeable evolutionary effects. Players have the power to make environmental changes on their own island, such as increasing temperature, adjusting the local flora, and even introducing a virus. By collecting data over many generations and looking at the proportion of certain traits in their population, players discover evolutionary trends and learn to predict future population changes.

Island Hoppers poses an interesting design challenge because our goal was to take a very broad topic, evolution, which often contains many misconceptions for students, and break it down into bite-size chunks. We ultimately did this by specifying formulas for the back-end simulation, which enable players to fast-forward through time step by step to research each relationship. One element unique to *Island Hoppers* is the graphically represented

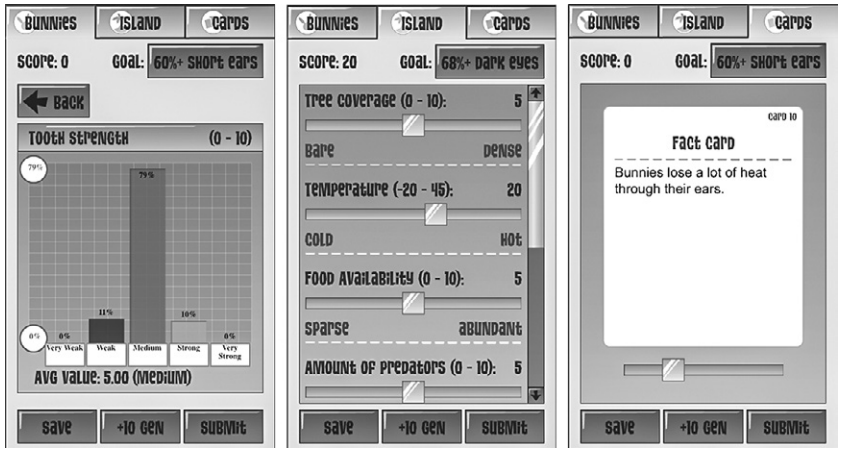

Figure 6.3
Island Hoppers screen shots

data and the use of histograms to display the breakdown of certain varieties of bunny traits (figure 6.3). Reading graphs is an important skill in science that is sometimes overlooked, so teachers value this feature. At the same time, the graphs provide information on whether players are making the right moves, so students are motivated to learn to read them.

Chomp!: Food Webs

> Premise: Mysterious species are connected in complex food webs that are under attack. Aliens have been chomping on these ecosystems, and each time they decimate one species, it has a drastic effect on the other interconnected species. Players must examine the relationships between species to understand and predict the population increases and decreases. If they can use this knowledge to determine which species was the latest victim, they will be able to restore the food web to its balanced state!

The main goal of *Chomp!* is to give students practice reading the energy flow of a food web (figure 6.4). It presents just two modes of difficulty, offering relatively less game play than the other games. Like *Invasion of the Beasties*,

Figure 6.4
Chomp! screen shots

Chomp! uses fictional species content, which in this case compels players to think about the predator-prey relationships rather than relying on prior knowledge of real species. Because each food web is generated procedurally, no two players get the same sequence of puzzles, though the generated food webs do increase in complexity. As a result, instead of players' sharing the specific solutions they find for each puzzle, they are encouraged to explain the overarching concepts to help each other.

More Ubiquitous Games

The Education Arcade has created two other ubiq game projects that have both similarities and differences to UbiqBio. Educational games from other designers also share elements of this genre and are useful to compare, although we wouldn't classify them as ubiq games. These examples should help clarify what ubiq games are, while also highlighting the design principles that make ubiq games successful and unique.

Weatherlings

Weatherlings is a ubiq game developed in 2009 in collaboration with Nanyang Technological University in Singapore. It is an online collectible card battle game designed to be played on mobile devices but able to be played on any computer with a web browser. In *Weatherlings*, players manage a

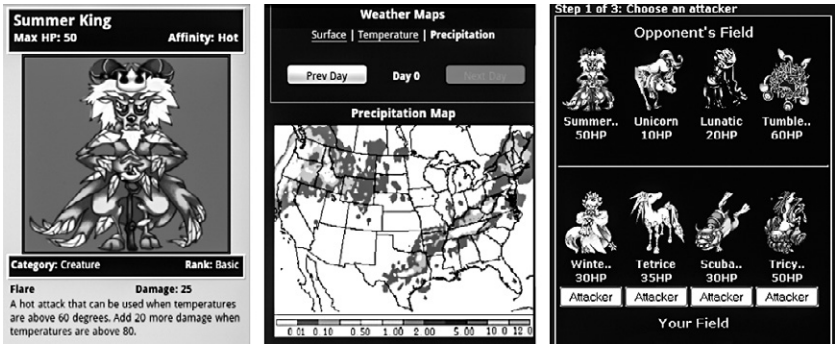

Figure 6.5
Weatherlings screen shots

collection of cards representing weather-dependent creatures and pit decks of their cards against other players' decks in battles (figure 6.5). These battles are set in actual US cities for which the development team has collected real weather data from the recent past.

One of the unique game-play elements of *Weatherlings* is the peer-to-peer interaction. While part of the game play involves deck building—collecting creatures and curating them into collections based on their strengths and weaknesses to prepare for battle in certain climates—this task is in preparation for battling with other players. That part of the game play consists of challenging other players to battle in arenas under certain weather conditions, which they must predict based on weather data. Peer-to-peer battles are turn based and can take place asynchronously, though players do often battle when they are physically sitting next to each other.

As part of the *Weatherlings* research done in a Singapore middle school (Klopfer et al., 2012), researchers collected data regarding the nature of student pairings. This research shows that the average student had 9.6 unique opponents (SD 4) over the course of four days. During the debrief discussion, students reported that they not only played against their friends (60%), but also played against whoever was available (75%). This is promising for ubiq games implemented in classrooms because it shows that if a mechanic is engaging, players will seek out people to play with, not limiting themselves to their group of friends. In fact, playing the game as a whole class provides players with more different people with whom to battle and discuss their outcomes.

This kind of social game mechanic serves some important purposes, in terms of both engagement and pedagogy. Many commercial games have a social element, and middle and high school students are social by nature. The ability to do things with your friends or classmates makes the game more appealing and fun. In addition, the interaction provides a basis on which students can have discussions, whether it be recapping a battle they just fought or comparing strategies. These discussions are likely to involve at least some of the game content and educational concepts conveyed in the game. For these reasons, designing a social interaction into a ubiq game can be a valuable component.

Palmagotchi

Palmagotchi was a game designed in 2008 for secondary classrooms to teach students about the principles of evolutionary biology. The game operated on each player's handheld device—at the time Windows Mobile Pocket PCs—which students borrowed to play throughout the school day. For each player, the game simulates an island with various species of birds and flowers, each of which has various traits, such as beak length, featheriness, flower depth, amount of pollen, and so on. These traits have relationships within the back-end simulation that can affect things like the likelihood of each bird pollinating a given flower, or the amount of food a bird can get from that flower (figure 6.6). Players interact with other players to feed on others' flowers and to mate with others' birds. Throughout the span of the

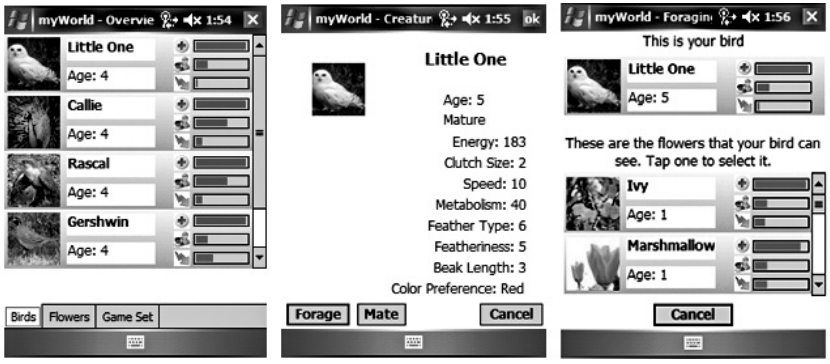

Figure 6.6
Palmagotchi screen shots

game, the players can observe how certain aspects of evolutionary biology play out.

Part of what makes the *Palmagotchi* experience so powerful and engaging is the affective element. Much like its inspiration the Tamagotchi digital pet toy, this game capitalizes on players' desire to care for their pets and help them thrive. Male and female students alike become very attached to their birds, putting special care into deciding whom they mate with, and getting upset when their favorite birds die. This adds a special kind of motivation to pay attention to the birds' traits and the environmental conditions, and to frequently take their devices out in the hallway or at lunch to check on them.

Another thing that the *Palmagotchi* implementation did well is that it connected in-class activities to the game play, to provide different views on the concept of evolution. While students played the game, they experienced a micro view of evolution, paying attention to the individual birds and flowers on their island. They made daily decisions about which traits they cared about, which birds to feed, and which birds to breed, and this let them see in detail how those decisions affected the traits of their birds. Then, teachers conducted a whole-class activity in which students documented on sticky notes information about the traits of their birds at designated points throughout the game-play period. The whole class compiled these data points into a histogram on the board, and from this, students began to identify patterns of evolution that occurred across the whole region or a group of islands. This experience provided a macro view of evolution, showing how the population of a species on the whole changed over many generations, which no one student could visualize during game play. The game content and the activity were well suited to the concept being taught, and the design of the two together made clear ideas in biology that can be very difficult to teach. This example shows that when ubiq games are integrated into a curriculum in thoughtful ways, they can bring about deep learning for students (Klopfer, 2008).

Statecraft X

Another thoughtfully designed game-based curriculum that fits well into the ubiq games genre is *Statecraft X*, created by the National Institute of Education in Singapore. As the developers describe it (Statecraft X, 2016),

Statecraft X is a 24/7 persistent-world, multiplayer game for students to construct meaning and identities in the context of citizenship education and social studies. The game is played on Apple iPhones. Its use is situated within the broader context of a learning program that explores how learning can be engendered across the boundaries of school, home, and other "outside" environments such as on the train and in the shopping mall.

In Statecraft X, students learn citizenship by playing the role of governors in a fantasy world. They have to ensure the total well being of the different peoples of the land, comprising trolls, elves, dwarfs, and humans. Satisfying the material needs and non-material wants of the citizenry being governed turns out to be a non-trivial matter. Support of the citizenry cannot simply be bought with money. Ideological issues have to be addressed. Coalitions have to be forged. Diplomacy has to be skillfully managed. Should players compete or collaborate for the successful development of statehood?

Game-based learning with Statecraft X seeks to create an open dialogic space within which issues related to the social studies curriculum and principles of governance at the secondary three level can be openly confronted and deliberated. Students' meaning making and identity construction are examined through the lens of the performance—narrative dialectic. Values and beliefs related to active citizenship are fostered through trans-contextual participation in game play that crosses the artificial boundary of in-school and out-of-school.

One aspect of *Statecraft X* that is worth drawing attention to is that it covers content in social studies. Although our previous examples all relate to science, ubiq games should by no means be limited to science or even STEM fields. Many concepts in humanities and social sciences can be a great fit for this genre, and the same design principles should apply.

Another key aspect is that this was designed as a complete *Statecraft X* program, with more in-depth curriculum than simply a game with some companion activities. Students that participated in *Statecraft X* played the game during out-of-class time over the course of three weeks, playing the role of governors in the game world. They also engaged in another fictional world that students created themselves using their imaginations. As a third component, they then investigated the governance of three real-world countries. Throughout these activities, teachers engaged students in meaningful dialogue, making connections between the three types of worlds. In a controlled study involving a postcurriculum essay task, researchers found that students who had completed the *Statecraft X* program wrote essays that "conveyed a strong sense of personal voice, awareness about current global and local issues, and an agency to act to achieve changes sought by the students," whereas the control group essays largely conveyed information read from a textbook (Chee et al., 2013, p. 24). This shows the power of a

good learning game that is accessible to students, combined with effective curriculum implemented during class time. The combination of modalities can strongly support deep learning in any domain.

Other Educational Games

Numerous other educational games have some but not all the qualities of ubiq games, and these make interesting comparisons as well. As this chapter delves deeper into the design principles most relevant to ubiq games, keep in mind what it looks like when educational games incorporate certain principles and not others.

Sandra Day O'Connor's iCivics project has published a game called *Pocket Law Firm*, which is an iPad version of the online game *Do I Have a Right?* In this game, players run their own firm of lawyers who specialize in constitutional law. They decide whether each client has a right and match them with the right lawyer (iCivics, 2016). iCivics also offers civics curriculum materials and lesson plans that incorporate each of their games. *Pocket Law Firm* is broken up into small rounds of game play since players have to deal with one client at a time, and if they create an account, they can save their progress. Picking up the game again after a break, however, may take some amount of ramp-up time, because they need to remember which lawyers they had in their firm and which amendments those lawyers specialized in. While iPads are technically mobile devices, we're not sure they're really mobile enough for a ubiq game, in that we hope students will play when they're out and about. Given these factors, *Pocket Law Firm* is more geared toward sitting down for an hour-long play session than fitting into the interstitial moments of a player's day.

Touch Press Games is another brand that distributes educational games with some commonalities to ubiq games. Their offering for schools, via the Amplify company, consists of bundles of iPad games for STEM and ELA, including titles such as *Twelve A Dozen*, in which players must use their factoring skills and solve order-of-operations puzzles to save the world, and *The World of Lexica*, in which players explore a virtual world where they can play embedded ELA games and are motivated to read independently (Amplify, 2017). Touch Press Games has a unique implementation model in which they sell game bundles to schools and provide teachers with access to student data, but students are encouraged to play outside class, according to their own preferences. This means that students choose what games

they're interested in and therefore may not be playing the same games at the same time. This certainly has its benefits but differs from the ubiq model, in which teachers can draw on students' shared experiences to conduct in-class activities. While some of the Touch Press games are more long form, like *Lexica*, and others are more casual, like *Twelve A Dozen*, they are all likely to be played in longer sittings on the iPad rather than on-the-go or in varied locations. Because of the iPad form factor, this characteristic is common to many educational games. While it doesn't detract from the quality of a game in any way, it does highlight the unique aspect of ubiq games, which are designed to be easily integrated into students' busy lives.

Designing Ubiq Games

We have just seen some examples of educational games that have similarities and differences compared with ubiq games. Naturally, countless casual games, which people play during spare moments of their day, don't attempt to integrate any educational content. These casual games provide us with some basic design elements that form the foundation of our ubiq games. While the goal of ubiq games is to provide a space to explore certain curricular concepts, they also need to be fun, playable, overall good games. To accomplish this, we rely on the work of casual game designers and scholars to inform our designs. Jesper Juul (2012) describes these five basic elements of casual games:

- **Fiction**: the way the game conveys its story to the player, which is typically positive and familiar for casual games.
- **Usability**: the way the player interacts with the game, which is typically via familiar controls or interfaces with thoughtful, easy-to-use design.
- **Interruptibility**: the frequency at which the game play can be interrupted while still making progress—typically casual games can be interrupted frequently both through controls (like pause) and by breaks in the flow of the game, such as those naturally occurring at the ends of levels.
- **Difficulty and punishment**: how hard the game is to start and proceed, and how severely the player is punished for failing—typically casual games provide an easy on-ramp for players but may develop into quite challenging games. They do, however, frequently allow the player to fail without harsh consequences.

• **Excessive positive feedback, or "juiciness"**: the frequency and presentation of positive reinforcement for doing things well in the game—typically casual games provide a lot of gratifying feedback (both audio and video) for doing even small things right.

These elements can clearly be seen in wildly popular mobile phone games such as *Candy Crush*, *FarmVille*, *Angry Birds*, and many more. They have a cute aesthetic and are easy to learn to play. They consist of short rounds and can easily be paused or saved for later. They increase in difficulty, but not drastically, so that players can keep playing long term. And they frequently mark accomplishments in leveling up and unlocking new tools. People enjoy playing these games, and they are motivated to keep playing them, at various times of day and in a variety of settings. These are some of the key elements that we want to transfer to ubiq games, while infusing the games with learning objectives and building quality curricula around them. The design principles that we consider more specific to ubiq games are detailed in the rest of this chapter, and should be considered as building on the foundation of the well-established casual game principles.

Adaptive Experiences

The Principle of Designing Adaptive Experiences
Mapping the game's leveling system to a sequence of increasingly complex skills provides scaffolding and motivation for players. It also presents more opportunities for player agency and cross-curricular connections.

When applied	*When not applied*
Games that have carefully designed levels that map to content and skills pack more punch in one game. They are more appealing to teachers, who can connect the game to multiple areas of their curriculum, and they keep students engaged for longer, giving them larger goals to work toward and more agency in game play.	Games that have practice-based rounds or a variety of content without skill progression also serve a purpose as a learning experience. For instance, they can present more exposure to different examples of a concept. But they don't usually have the same impact on a player, either in terms of learning objectives or integration into students' lives.

Casual game mechanics result in bite-sized game experiences that come together to form a larger challenge or undertaking. For example, in *FarmVille* and other games like it, each time you log in, you collect resources that have accumulated, you build new structures, and you check in on your friends' farms. But the overarching project, which you work toward little by little, is to build a thriving estate decked out with all the agricultural accessories you could want. When we apply this format to learning games, we must also think about the sequence of those smaller actions and how they build concept understanding over time. Based on the suite of UbiqBio games, there are two main ways to think about the function of these rounds, or levels.

Practice-Based Rounds

Practice makes perfect, and applying the same skills or processes to slightly different examples can be a good use of games. Especially in a classroom setting, where students are all given the same amount of time on a unit regardless of whether they understand it, a game in which students can practice as much or as little as they need can be quite helpful. In this case, the game contains a large quantity of replayable content, but the game mechanic stays the same. *Island Hoppers* illustrates the idea of practice-based rounds. It presents different bunny traits and different numerical goals, such as get 60 percent short ears, get 90 percent long ears, and so on. Yet the action of each round remains the same, which is to identify which environmental condition affects that trait, then make adjustments that will result in the desired population changes. Players are exposed to a wider variety of examples of relationships between selection pressures and traits, which can help them abstract the idea of natural selection. They also have the opportunity to read histograms in every round, which is a skill that becomes more natural the more you look at those charts. So these are some of the ways in which practice-based rounds can be a valuable way to design a game, even if it may not seem as rich as adaptive leveling.

Adaptive Leveling

Creating distinct levels within a game, which present qualitatively different actions or skills, is another important tool in a game designer's toolbox.

Commercial games do this all the time to keep players engaged and challenged, but in a learning game, that progression needs to map to a logical sequence of skills that build on each other, and the pace becomes more important for students at different starting skill levels. *Beetle Breeders* was designed with a leveling system that takes students through a series of increasingly difficult inheritance patterns, adds dihybrid crosses into the mix at the appropriate point, and requires multiple generations of crosses as part of each of those difficulty levels. Within a level, the orders to be filled are of the same challenge type and difficulty, but players must complete a certain number of them before they are deemed ready to move on. This means that if players are having trouble filling the three orders necessary to complete level 1, they will stay on level 1 for longer than players who already understand complete dominant traits. Those players who need more practice will be able to spend time on those level 1 orders, only moving on when they seem to have mastered the concept.

In our UbiqBio pilot study, we saw that both time spent and level achieved ultimately correlated with success in class. In *Beetle Breeders*, the leveling system meant that early success in the game triggered more difficult concepts, which extended student learning. Players delved deeper, spending more time and more effort to ultimately engage more deeply with the content, which led to improved results on a postgame assessment (Perry & Klopfer, 2014).

Beetle Breeders bases its progression rules simply on the number of orders completed, but it is certainly possible to have more sophisticated algorithms to determine whether players are ready to move up. This could include factors such as how many orders they have successfully filled in a row, or details on specific mistakes they may be making. There have even been attempts in games to program complex AI that will guide students on a path through the game that has been determined to be the exact right one for them. The type of adaptive leveling with more player agency that we describe, however, in which players choose what to work on, within a "smart" framework of challenges provided, can in fact be more useful for students and certainly less resource intensive.

Comparison

Adaptive leveling necessitates that additional game mechanics be built into the games, and it means curriculum designers need to design the

sequencing pattern and guidelines. All of this requires more development time, user testing, and tweaking, which increases the scope over a game that uses practice-based rounds. Nonetheless, it adds value in terms of educational content packed into one game, which is a plus for teachers choosing their curriculum, and it adds to the ways in which games can make connections across levels and even outside the game to other concepts. Keeping students challenged, with just the right amount of difficulty, means they will be more engaged and stick with the game for longer. Both can lead to more exposure to the content, deeper learning, and memories of the game experience that stick and are then carried through to other aspects of players' lives.

The Codesign Process

The Principle of Codesigning with Educators
There are many ways to involve practicing teachers throughout the game design and curriculum development process. Doing this ensures that the content and premise are relevant, and that the surrounding curriculum is effective and usable.

When applied	*When not applied*
The collaboration of a game designer and a current teacher means that expertise in multiple areas is brought to the project. Games are more likely to address standards that are a real need for teachers, and appeal to students in the target grade level. In addition, the curriculum developed is more likely to feel accessible to other teachers and to fit easily into a realistic classroom setting.	Game designers working in isolation may have educated guesses at what content should be covered and how best to design curriculum, but without frequent input from practicing teachers we often end up with a disconnect. The final product may prove tricky to implement in a real classroom, and the game may unknowingly promote misconceptions that we want to fight against. These issues can then emerge later in the testing process when it's more difficult to make changes to the project.

One key to a successful creative project is bringing together the right team members. We wouldn't expect a biology teacher to be able to design a great

game, and similarly we don't expect game designers to know the nuances of teaching biology. In our experience across various projects, bringing these two areas of expertise together results in products that are both good games and good learning. We've found one effective way to do this is to collaborate with practicing teachers who join the team as consultants. There are many benefits to this model, and the UbiqBio games are a good example of our collaborative process.

Brainstorming Phase

We find it helpful to involve our teacher partners at the earliest brainstorming phase, when we are deciding the topic of a game. Teachers know best what content is covered in their standards and how much time out of the school year is spent on that unit. More importantly, they have insight into which topics are already taught well, are rife with quality resources, and are easy for students to learn. Those are not the topics we want to be covering in a new game, so we look for the challenge areas, where teachers say their students struggle with the content and need more personalized or in-depth ways to get at a concept. In planning for *Beetle Breeders*, although there are a lot of teaching materials about genetics, teachers said it was hard to give students opportunities to practice breeding in a hands-on way. So we decided that a simulation-based game with the ability to experiment with a creature's traits would be a unique experience for genetics students.

Teachers not only bring their content knowledge to bear, but also are valuable experts on the habits and preferences of their students. When we begin brainstorming game types or narrative premises, teachers provide useful feedback on whether an idea is age appropriate for their grade level, whether it's too hokey, or whether it's something they can see students in their classes latching on to. And of course, these teachers don't have to be omniscient about their students' likes and dislikes because they can easily ask the experts—the students themselves. While designing our *Invasion of the Beasties* game, there was some debate about who the characters should be—zombies? vampires? These were some of the popular characters in youth media at the time. But teachers chatted with students, some of whom thought zombies were played out, and others who had negative associations with those mainstream media icons. So in the end, we stayed away from those trends and stuck with monsters, which seemed more timeless and universally appealing.

Design and Testing Phase

During the design phase, we periodically show mockups and prototypes to our teacher consultants to get their feedback. This provides an opportunity to correct any inaccurate content, and it also opens up deep discussions about student misconceptions. Sometimes games accidentally reinforce a misconception rather than dispelling it, and teachers who deal with those misconceptions every year are quick to point out those cases. While experimenting with game mechanics for *Island Hoppers*, the game about natural selection, we had to choose whether the action taken was changing the population in some way, changing individual traits, or changing the environment. Teachers described one of the most challenging misconceptions to combat, which is the idea that an animal can change its traits because it wants to, simply by willing its fur to grow longer, for example. One goal of the game was to make it clear that this is not possible, that no individual can change their DNA and therefore their phenotype. So we realized we needed to stay away from any agency in changing bunny traits, and put the emphasis instead on the changes in the environment. Letting students adjust the climate of the region, making the island warmer or colder, still gave them agency but kept it one step removed from the misconception we were worried about. Making the island colder and then advancing many generations would mean short-haired bunnies froze to death more often and long-haired bunnies reproduced more often, resulting in more long-haired bunnies in the population. This put the focus on the relationship between the environmental condition and the population's traits, which was at the center of the learning objectives.

Rapid prototyping and frequent user testing is a technique we employ as much as possible. Working with teachers who have their own biology classes and were enthusiastic about the project meant that we had ready-made testing groups. It was easy to visit their classes and try out ideas with their students, or even come after school and do informal interviews or small focus groups, because they were involved in the process and wanted to see things in action for themselves. Finding students in the target demographic and scheduling time with them is not always easy, so teacher consultants can help support those efforts.

Curriculum and Implementation

As discussed in previous chapters, the connections between a learning game and the rest of the curriculum is a key factor in the effectiveness of

resonant games. A standalone game with no facilitated reflection on the skills or content or what they mean can't be expected to have a great impact on student learning. The UbiqBio games all had a suggested sequence for the unit's curriculum, with companion materials designed to help students take concepts in the games further and facilitate transfer to other relevant contexts. For example, the *Island Hoppers* curriculum included activities directly related to the game content, challenging students to think of additional bunny traits and their potential selection pressures. It also related the concept of natural selection to other species via a nondigital simulation of birds. In this activity, students take on the role of birds with different beak shapes as represented by plastic forks, spoons, and knives. They physically try to pick up marshmallows, which represent their food source, with their beaks. Some beak shapes are better suited to this task, and those birds flourish while others tend to starve to death. In this activity, students found out experientially which birds were more likely to live and die, and they could draw parallels to relationships they had explored in the digital game. Creating the bridge curriculum such as the beak-marshmallow simulation, and sequencing the activities, was one of the main responsibilities of our teacher consultants. They were experienced with integrating technology into their curriculum and had a repertoire of tried-and-true activities to choose from for these lessons. For these reasons, they were particularly well qualified to help design a curriculum that would help the UbiqBio games resonate in multiple ways with students.

Once the games and curriculum were ready, the next step was to begin rolling out the offering to teachers participating in our study. For this project, it was a small number of local teachers, but in other resonant game projects there could be wide-scale outreach and implementation. In either case, hearing the voices of fellow teachers and knowing that the game and other activities had been used in real classrooms made the project more credible and feel more accessible to teachers who might otherwise have been reluctant to try a mobile game with their students. In this way, teacher consultants help create the product, but they also help generate interest and adoption.

When Not to Listen

After detailing the myriad ways in which teachers can contribute to a learning game and complement the skills of a game designer, we should also

note that at times, it's important to disagree with their perspective and even their pedagogy. When designing resonant games, we do want the game to be feasible to implement and fit within the existing constraints of the classroom. But only to a certain degree, because we are also trying to move the needle on innovative pedagogies such as student agency and constructionism, which often don't fit easily in a traditional classroom setting. In addition, digital games as part of formal education is still a new idea for many people, and this includes students themselves. Initial feedback and observations may indicate that students aren't comfortable with certain elements or don't easily engage in reflection activities. But if teachers come back and say this didn't resonate with my students, sometimes we don't want to dial it back but would rather keep it up to give everyone involved a chance to experience a new way of learning. This is the dance of the resonant game designer, who must take into account feedback from all team members to determine when an experience needs to be familiar and when it needs to challenge expectations.

Integration into Life and School

The goal of our ubiq games is to infuse learning experiences into students' lives, both inside and outside school, in a way that is motivating and engaging. The games do this by using devices and game-play styles that students are already comfortable with and that fit easily into their daily routines. This may look different for different students—when they play and how much they play at a time is completely up to them. The following is an example of one way in which students may experience this genre of game.

Thalia is a ninth grader on her way home after school and volleyball practice. She's tired after a long day and not looking forward to the pile of boring homework she is supposed to do, so she's thinking about skipping it. She gets on the bus, sits down, and takes out her smartphone. She puts in her earbuds and turns on her current favorite music. She sends a few texts and checks Facebook. Then she switches to the web browser and navigates to a game called *Invasion of the Beasties*. In this game she has to genetically engineer a monster so it will be able to defeat the evil enemies. Thalia likes this game because it has quirky characters with funny pictures, and it's fun to advance through the levels. Her teacher has

assigned everyone in her intro biology class to play the game, but Thalia doesn't think it feels like school. It's obviously about mRNA—there are nucleotides and amino acids—but it's like a puzzle you have to figure out, and she wants to see if she can beat the game before her friends do. Plus she's always on her phone anyway, and she can fit this in on the bus and between classes. Thalia has played five rounds when it's almost time to get off the bus, so she puts her phone away, knowing that the game has saved her progress so she can pick up where she left off later tonight.

Playing during interstitial moments of the day—on the bus, waiting in line, between classes—is one of the primary ways in which designers envisioned ubiq games could be used. But this is by no means the only way, and even within this model is a great deal of flexibility. Some students may choose to sit down and play for a longer chunk of time, perhaps as the first piece of homework they decide to work on, or perhaps as the last thing of the day as they get into bed. Some students play primarily during school hours, even sometimes sneaking their devices into school (Klopfer et al., 2012) or secretly playing during other classes. While not endorsed, this behavior does speak to the appeal of the games and format! Some students end up working the game into a routine, playing at the same time of day each day, such as when they're waiting for the bus; while others have more varied schedule, with work and afterschool activities, and find it more convenient to play at different times each day. Students can play on their own, or while sitting next to friends who are also playing; they can text their friends about what level they're on or wait until the next day in class to compare strategies and ask for help. Some students even share the game with other family members by playing at the dinner table or getting their siblings to help with the tricky levels. The takeaway here is that regardless of how students played, most were able to find ways to integrate the game into the fabric of their lives. Adding a different kind of schoolwork didn't mean they had to find time to get to the computer lab or rearrange their schedules. The ability for students to make a game their own and control how much and when they play contributes to their ownership and adoption of the game. This, in turn, enables the game to become deeply embedded in their lives and to provide a new kind of ubiquitous learning experience.

Games that Fit into Everyday Life

The Principle of Integrating into Everyday Life
Because fitting a game into students' busy lives can be a challenge, the game mechanics and format must be thoughtfully designed to work within the constraints of either in-school or out-of-school time.

When applied	*When not applied*
Game designers who carefully consider where and when their game should be played, plus what variations there may be, will end up with a game that is much more likely to be adopted and embedded into players' lives. They will not only have access and time to play the game but can really embrace it, letting the game become part of the fabric of their lives for a time.	Game designers who don't think about where and when the game will be played, or who assume the game will fit into any context, are more likely to end up with a game that doesn't get a lot of traction, even if the game itself is great. If players can't find enough time to play, or have trouble accessing the game from places they want to play, they won't end up getting into it even if it initially seems appealing.

As the examples above show, we have seen students integrate ubiq games into their daily lives in many ways. The fact that students do this in so many different ways (when, where, how long, how often, with whom, etc.) shows that the merit to this model of game play. We also must acknowledge that the design of the games, both the format and the mechanics, contribute to the flexibility and personalizability of the genre. Through the process of designing, building, and researching the four UbiqBio games, along with *Weatherlings* and *Palmagotchi*, we have extrapolated some common design principles that together make up the principle of integrating games within students' current daily lives.

• **Short but meaningful experiences**: Game play is split up into bite-sized chunks, where each chunk lets players do something involving the science concepts, such as breeding a generation or two of beetles, or balancing a food web. Players must do some thinking to accomplish something in each chunk, but they can decide for themselves how much to play in one sitting.

• **Ability to easily resume play**: Each new challenge or level doesn't require a lot of exploration or startup time. There are differences that keep it fresh, but each one is familiar enough that players can pick it up and keep going even if they have only a few minutes.
• **Continuous saving of progress**: Player actions should be saved automatically and frequently so that when players get interrupted by other things in their lives and have to put the game away, they will know they can pick up where they left off with a smooth transition to the next play session.
• **Engaging leveling system**: Play sequences in the game build in content, challenge, or simply number, leaving players wanting more and looking forward to the next time they can pick up the game. Mechanics are engaging enough that students think about their strategies even while not playing, and are motivated to talk about them with friends.
• **Ability to reference game elements**: Players can easily talk about the game together because the elements of the game, such as characters, levels, or tools, are clearly labeled and memorable or intuitive. This makes it easy for players to quickly ask each other questions about feet stickiness or the universal genetic code without having to look back at the game or check what they were working on.
• **Social experience**: Game mechanics that require interaction with another player, either synchronous or asynchronous, can benefit both learning and engagement. Players are encouraged to discuss concepts together to work out the challenge, or are motivated to beat their friends by taking their skills to a higher level. Players expect a lot of social interaction on their mobile devices, especially outside the classroom, so opportunities for collaboration can boost appeal as well as impact.
• **Fun and appealing**: A good casual game should appeal to many types of players, and studies have shown that our ubiq games are enjoyed by both boys and girls equally (Klopfer, 2008; Klopfer et al., 2012; Perry & Klopfer, 2014). As games that are played on students' own mobile devices, they are inherently competing with other games and apps students have on their phones. All the above design principles help ubiq games to be playable and engaging, but the number one way to attract players is to make the game narrative and mechanics intrinsically fun!

This complement of game design factors, when cleanly integrated into a game experience and used wisely, can lead to the variety of outcomes presented at the beginning of this chapter, which make the ubiq games experience unique. They ensure that a game works well and is easily accessible on a device that students already use. They enable students to play in short, frequent bursts, often during interstitial moments of their day. And they allow students to become deeply engaged with a game and with each other. It should be noted, however, that these particular factors need not function as a checklist for game designers, nor should they be considered an exhaustive list. A good ubiquitous game or a good resonant game need not incorporate every factor to be successful. Rather, this may be considered a pool of ideas to start with and draw from as you design games with goals similar to our ubiquitous games.

Games that Fit into the Classroom

While one of the main goals of ubiquitous games is to integrate smoothly into students' lives, to be used well, they must also integrate smoothly into the classroom and into teachers' pedagogical practices. This means supporting and extending existing curriculum, providing the teacher with information on how students are doing, and giving teachers the flexibility to implement the game as they see fit. The following is an example that illustrates the teacher experience of ubiq games.

Ms. Geary is a high school biology teacher finishing up some grading and getting ready to head home. The quizzes she's grading are tedious, so for a quick break she opens up the teacher website for *Invasion of the Beasties*, which she has assigned her students to play. She checks to see who has the highest score today, and while the usual students who reliably do their homework are indeed in the top five, she's pleasantly surprised to also see Thalia listed there. Ms. Geary has always seen Thalia as a perfectly capable student, but it's been hard to get her engaged in any of the biology content she's taught this year. Looking at the stats, she is happy to see that Thalia has been playing about thirty minutes each day this week, and considering the high level she has reached, Ms. Geary knows that Thalia is understanding the topic of mRNA and the translation process. If she wasn't able to use the universal genetic code, she wouldn't have earned such a high score in the game, so the data are very promising.

Ms. Geary closes the page and reminds herself to congratulate Thalia in the morning and make an effort to encourage her to share with other students the strategies she's developing. While these mobile biology games are fun and engaging for many students, one of the most valuable things Ms. Geary has found is the way they also stimulate content-rich, authentic conversations.

Aligning with Standards and Curriculum

As with any piece of curriculum, for ubiq games to be used by teachers, they must be aligned with standards and fit within a typical unit. This doesn't mean they have to use traditional pedagogy or approach the topic in the same way teachers always do, but they must have clear connections to what teachers already cover. For deep learning, it's important that these connections be not only to content standards, but also to process-oriented skills, STEM practices, and even soft skills. Without that stated explicitly, teachers could rarely make time in their packed curriculum to cover something additional. As part of being aligned to existing curriculum, the game should have a clear progression in terms of the content level, subtopics, or skills presented. This often takes the form of a teacher's guide they can quickly refer to, to know things like which inheritance patterns are covered in which levels of *Beetle Breeders*, or what skills are being built as information is gradually taken away in *Invasion of the Beasties*. Having this information clearly laid out helps teachers select games to use in their classrooms, and integrate them into their curriculum in meaningful ways.

Another essential piece for integrating ubiq games, and indeed any resonant game, into a classroom is supplementary materials that tie the game to the existing curriculum. The principle of making curricular connections is discussed in more detail in chapter 5, and it applies in many of the same ways here. Ubiq games are designed for students to play on their own time, and to build skills and concept understanding at their own pace. Yet, they are not designed with the goal that students will learn everything they need to independently. In our experience with resonant games and educational technology in general, the game builds a foundation, but knowledge is solidified and extended through reflection and collaboration, best facilitated by the teacher. While UbiqBio teachers' implementations varied, they

were encouraged to have students play the game before formal instruction took place, or at least near the beginning of a unit, to allow for the sequence of game play followed by reflection and further instruction. As described in chapter 3, the principle of preparing for future learning tells us that a valuable function of resonant games is building a foundation of understanding for students and teachers to build on in this way. Some superstar teachers do this naturally and are able to come up with their own bridge activities and companion materials, but it would be an unreasonable expectation for all teachers to do that well on their own. For this reason, a key piece of the UbiqBio offering was the curriculum and activities, designed by our teacher consultants, that went with the games. These activities provided some context for teachers to dig deeper into what students were doing in the game, explaining more about the genetics and supplying useful terms. They also enabled teachers to generalize more abstract concepts from specific in-game contexts to examples involving other species or how mRNA

The Principle of Connecting Data to Practice
To effectively provide teachers with data, designers need to carefully plan what data should be collected, coordinate that with the game design, and support teachers in how to use that information to inform their classroom practice.

When applied	*When not applied*
The right amount and the right kind of student data, displayed in an accessible teacher dashboard, will be welcomed by teachers. With training or resources for how to make sense of that data and how to use it, teachers will be able to check the dashboard regularly, then focus their class discussions or adapt their labs and activities according to the students' needs. This results in a game that is well connected with the rest of the curriculum and learning experiences in the classroom.	Too often when data are provided to teachers, they are either superficial or overly complex, either of which results in little information on student learning. Other times, even with useful data displayed, teachers new to game-based learning may not be familiar with how to interpret the data or what they can do to connect classroom activities to game-play experiences. This results in a game experience that is disconnected from the rest of the curriculum—a missed opportunity to engage students and solidify learning.

functions in other biological processes. This meant that students were reflecting on what they had learned in the game and applying it to new situations, thereby engaging in transfer—one of the most challenging processes in education.

In addition to concrete activities included in the supplementary materials, there was time built in for class discussion, and prompts to scaffold that time for teachers. Whether or not a game has social interaction built into the game play, the social experience that exists outside the game can be equally important. In UbiqBio, many teachers were surprised at how much collaboration they saw among students discussing strategies, asking for and giving help. These interactions involved discussing biology concepts and teaching others, which can be hard to bring about in a traditional classroom. This shows just how important face-to-face class time can be, even for a game played entirely outside of class.

Connecting Data to Practice

The UbiqBio games came with another important tool—the teacher dashboard, a website teachers used to track student progress (figure 6.7). The data-logging system collects player information which is then displayed to teachers so they can easily track participation. Along with game data, such as score and level, the games also log other types of data that describe play patterns, such as how long players spend in each area of the game, and how many times they log in. In addition, designers can collect data that will reflect how well students understand the material and therefore help teachers assess their progress. These data are displayed in the teacher dashboard to let teachers quickly see how much their students are playing, and what they are getting out of their play time.

Designing a teacher dashboard to convey information about student participation and progress in a game should be taken seriously. To be successful, it should be considered a major piece of the project and should have work put into it throughout the game design process, rather than as an afterthought. One reason for this is that the data collection needs to be built into the game and must be woven together with the game's learning objectives and mechanics. Considerations around what to collect and what is meaningful are likely to affect the specifics of those game mechanics and the user interface, and for this reason, neither one can really be completed

Login	Name	Current Level	Current Balance
player_1	Maria	1	$100
player_2	John	4	$518
player_3	Hector	6	$1,104
player_4	Shawna	1	$100
player_5	Angel	2	$149
player_6	Kai	6	$1,067
player_7	Thalia	2	$118

Figure 6.7
Beetle Breeders teacher dashboard sample

before the other (Groff et al., 2015). In addition, the teacher dashboard won't be used or useful unless it provides meaningful information to teachers in a convenient format, and the best way to ensure those factors is to continually get feedback from teachers. This can mean running mockups by the teacher consultants, or including the teacher dashboard in early prototype testing. While teachers feel it is essential to have data on their students' game play, they don't want to be inundated with information they see as extraneous.

Aside from the design of the teacher dashboard, the other tricky piece of integrating it into a game-based offering is working with teachers on how to use those data. Teacher feedback and user testing can tell you a lot about what data teachers want and how they are likely to use those data. But for a resonant game to have the most impact it can, existing habits may not be enough. This is another case where providing innovative tools can help move the needle on what teachers are doing. Providing data teachers may not have thought to ask for, along with training on how they can use those data to inform their classroom practices, can deepen the impact of the learning experience for students while also giving teachers new pedagogical tools they may not have been comfortable with before.

During the UbiqBio project, we found various ways in which teachers were quite comfortable using the teacher dashboard. They periodically checked the level each student had gotten up to, or the amount of time each student had played, usually depending on the metric they had assigned students for game play, to see whether the student had met requirements. Teachers who felt their students would benefit from competition would

even post the daily high scores to generate excitement. They also used the basic data in multiple ways to determine which students they needed to catch up or check in with. For example, if they noticed a student had few points but had played a lot, they might guess that the student was struggling with the content. If they noticed a student had few points but also hadn't played for very long, however, they might check in to see whether the student was having technical difficulty or just hadn't bothered to play yet. These strategies felt accessible and were easy for teachers to incorporate into their formative assessment and teaching plans.

There were other dashboard uses that fewer teachers tried, or that teachers mentioned as being useful in theory but that they didn't do very often. For example, purposely connecting students to facilitate collaboration. If they noticed a student who had many points or had played through high levels, that student could be encouraged to help out other students who might be struggling in that same game. It takes a little more work to identify what students are struggling with, match them up, and scaffold how they can help each other, which is why most teachers were more likely to let collaboration happen organically. Another more nuanced way to use the teacher dashboard would be to map specific game actions to specific learning objectives. With relevant data provided, a teacher could notice which level a student may have been stuck on for a couple days, or even which genetic crosses the student had been attempting unsuccessfully while working on a certain contract. The teacher could then refer to the teacher's guide to confirm which inheritance pattern that level focused on and check to see if multiple students in the class were having trouble with, for example, dihybrid crosses involving codominance. Armed with this information, teachers could adjust their practice by pairing these students up with students who already had strong breeding skills in codominance, or by pairing students with unique strategies to generate discussion. They could use class time to review that inheritance pattern or explain it further, and they could provide additional activities or resources outside the game to get at that concept from a different angle. These are some of the ways in which teachers can effectively use student data to inform their teaching practice, but it won't necessarily happen spontaneously. On the contrary, this type of opportunity must be thoughtfully designed into the game and tools, and teachers must be provided with resources, training, and examples of how best to integrate those tools into their classroom. This process

takes work from the game and curriculum designers, as well as the teachers, but it pays off by resulting in a more meaningful game experience for all involved.

Flexibility of Use

In many of our resonant game projects, we emphasize the ability for teachers to be able to implement the game however they see it working best in their classrooms. Schools, classes, and students all have their own character and their own constraints, so for a game to be successful, it must be allowed to be molded to fit the context. We also emphasize the need for teacher resources—curriculum materials, reference guides, and professional development opportunities—as a way to support teachers. It must therefore be noted that in designing the game, its implementation model, and the supporting materials, designers must strike a balance between offering advice on how to best implement the game and letting teachers figure out for themselves what works best.

The UbiqBio games serve as a clear example of this balance. With four separate games that form one larger experience, there was room for teachers to try things and improve on their implementations. Each individual game was small enough that even with the supplementary materials, it felt accessible to teachers—it was manageable to fit into their curriculum, and they could wrap their minds around how to adapt the game to their needs. This was more doable with UbiqBio than with a bigger, long-form game like *Radix*, which took more commitment and investment up front.

The teachers that implemented the UbiqBio games as part of our pilot study did have certain elements in common in their approaches. They all introduced the game in class, assigned it in some way, let students play on their own time, and conducted some amount of the supplementary curriculum during class time. Within these approaches, however, were many differences.

- **Use**: The function of the game within the curricular unit was one of the main choices teachers had to make. Sometimes it was used before teaching the content, in accordance with the preparation for future learning approach. Other times it was used during the unit, especially with a game that has a content progression such as *Beetle Breeders*; teachers could assign relevant levels as they taught those inheritance patterns. The games were

also used after a unit, either as additional practice on things like Punnett squares, or as review of a concept taught earlier in the year, which many teachers did with food webs. Selecting the timing and function of a learning game is an important decision that can affect many other aspects of a teacher's implementation.

- **Requirements**: Most teachers gave some type of requirement for students playing each game. For example, play to level 10 by the end of the week, or play for at least twenty minutes a day. These were metrics they could track and in some cases use to assign a homework grade. Other times they made the game optional as an extra credit assignment. Overall, teachers were pleasantly surprised with how much students played beyond the specified requirements.
- **Competition**: Some teachers found competition to be a useful tool to generate excitement in the classroom and to motivate students to keep playing. They would share high score lists and offer small prizes or recognition for top players according to various metrics. Other teachers felt their students would not react well to that and chose to keep results more private or to promote more collaboration instead. This element can work well in either direction and must be decided by taking into account students' personalities.
- **Bridge Curriculum**: The curriculum provided was divided into required activities, which designers had determined to be the highest priority materials to make connections with the game content, and optional activities, which added exposure or extended the topic. Teachers were free to use varying amounts of the optional materials, which they appreciated. They were able to pick and choose according to which areas they already had preferred activities for, and which topics they thought could be improved by new lesson plans.

Of course, many more choices than these go into the implementation of any game, and other aspects are discussed in other chapters of this book. These examples give a sense of the types of differences in teachers' implementations, from pedagogical approaches to logistical details. You should consider the similarities and differences you anticipate in the implementation of your resonant game throughout the design process, all the way through to the presentation of teacher materials. A game experience will feel most personal and meaningful by providing the right amount of scaffolding while also leaving room for teacher autonomy.

Conclusion

Designing a good resonant game is largely about finding ways for the game to become a cultural artifact, an experience that gets willingly adopted by your users and incorporated into their lives. There are a variety of pathways to this outcome, and ubiq games arrive there a bit differently than games like *Radix* and *Vanished*. Ubiq games are short form and have a narrower scope of content in order to fit the casual mobile game format. Their play experiences are bite sized instead of immersive. In a sense they are leaner and scrappier, infiltrating players' lives through the cracks. Yet these games also have key elements in common with the other resonant games we have discussed. They provide authentic experiences with the educational content, with hooks to make connections to other ideas and other aspects of students' lives. While in a literal sense a play session can be completed in five or ten minutes, experientially, the learning doesn't stop there. Like other, longer-form games, companion activities or curriculum only strengthen the game's impact, with each element building on the others to really resonate with players.

Like the everyday places you visit frequently, ubiq games may not seem like a major part of a learning experience the first time you open the game. But like those familiar locations, the more you visit and spend even small amounts of time there, the more ubiq games start to affect you and become a part of who you are. The unique characteristic of well-designed ubiq games is how they fit into players' lives, and stay in players' lives—namely by meeting players where they are, with a format that works on devices they already have and use regularly. Ubiq games can deliver content in accessible ways and can be a great fit for certain audiences and settings, whether played as the core learning experience or even attached to another, larger game. For these reasons, ubiq games are a pragmatic format with high potential to resonate with students.