
This paper takes a novel approach to gamification and utilizes concepts of pattern designs to articulate and study game interactions for the purpose of supporting learning. Pattern designs represent possible good solutions to problems, and gamification currently wants for this type of resource.

A first step toward this resource is shown here. It is accomplished through a methodical observational analysis of an extant game, where the design interactions within that game are identified and then evaluated for their appropriateness and usage.

Headings:

Interactive computer systems -- Human-computer interaction.

Computer assisted instruction -- Educational technology.

Educational technology -- Computers in education.

Educational technology -- Gamification.

Systems design -- User interfaces (Computer systems).
ANALYSIS OF INTERACTIVE DESIGN ELEMENTS IN A PRACTICAL APPLICATION OF GAMIFICATION TO LEARNING: KHAN ACADEMY

by
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Introduction

Gamification is the idea that real world activities can be imbued with game elements in order to make that activity more fun and motivating, and by extension, make a person more likely to engage in that activity (Floyd, Portnow & Siegel, 2011). Playing video games can be a valuable thing, and promote the learning of a range of skills that can have application in many areas (deWinter, Griffin, McAllister, Moeller & Ruggill, 2010; Kirriemuir & McFarlane, 2003). The application of game concepts to everyday activities today is broad, and has already been applied to marketing, the work place, education, the military, and even applications designed to promote physical fitness and civic awareness (McGonigal, 2010; Floyd, Portnow & Siegel, 2011). Regardless of the use, it is crucially important to note that gamification on its own is just a mechanism, and can have both good and bad applications - sometimes unintentionally so – and so efforts should be made to best understand its most beneficial applications (Shaffer, Squire, Halverson & Gee, 2005).

In this paper I explore human information interactions through design patterns in support of digital pedagogy. To accomplish this, I analyze gamified user interactions within a widely popular learning environment, emphasizing the efficacy and appropriateness of those interactions in supporting learning. These observations will contribute to the development of a common pattern language for gamified interactions that will give breadth and depth to gamification discussion.
The result of this process should help to serve as a roadmap forward for educators thinking about or wanting to apply gamified learning practices to their own classrooms, and as a reference tool for developers wishing to create more engaging educational software. Although this paper will focus on learning strictly in an educational or academic context, all academic and non-academic knowledge that people have is acquired through a process of learning, and so the gamified interactions explored in this paper can be further expanded to cover such issues such as how organizations train employees, or how people learn very practical skills such as managing finances.

There is an important need to understand gamification inside of a digital age where “computer and video games will become the predominate form of popular culture interaction in our society” (Gee, 2004). More than three-fourths of children play games on a regular basis, investing upwards of 10,000 hours of gameplay time by the age of twenty-one (McGonigal, 2010; Kirriemuir & McFarlane, 2003). Worldwide, a total of three billion hours are spent playing online games each week (McGonigal, 2010). The time spent playing games is increasing at the expense of other activities, and the clear preference of children toward the interactions afforded by video games needs to be studied (Kirriemuir & McFarlane, 2003). Despite the overwhelming popularity of video games, most of the educational games that have been produced have been done so without appealing to theories of learning or other underlying bodies of research concerning the specific interactions that precipitate designing for digital pedagogy (Shaffer, Squire, Halverson & Gee, 2005). From the standpoint of educators it is hard to know exactly how a particular
game might be relevant to some piece of curriculum, and also difficult to judge the appropriateness of the game as a learning device even when it is aligned with the curriculum (Kirriemuir & McFarlane, 2003). Additionally, educators don’t necessarily have the time to learn about the ways that games can be applied to learning. (Kirriemuir & McFarlane, 2003).

Gamification for learning using video games is not a new thing by any means – it only takes going back to the original Oregon Trail in 1971 to see that - but the maturation of the digital age and commensurate modern video games have provided affordances that were not always available on as wide a basis in the past as they are today. Because so many children already play video games, using video games or video game elements represents a convenient interaction point on which to engage with children and communicate ideas to that audience. Keramidas (2010) makes particular mention about how closely game environments resemble learning environments. Many of the skills and digital literacies acquired by children through daily interactions with computers and video games work to reinforce the interactions promoted by gamifying education (deWinter, Griffin, McAllister, Moeller & Ruggill, 2010; Kirriemuir & McFarlane, 2003).

Learning by playing video games fundamentally occurs through a process of human-computer interaction (HCI). Video games are systems made up of a number of user interactions, all which facilitate the transmission of some amount of knowledge (Paras & Bizzocchi, 2005). What this paper explores is the afforded interactions between a human and a system designed to promote a goal of learning
or motivating learning. The specific system that will be evaluated is the Khan Academy (www.khanacademy.org), a popular online learning resource that makes use of a number of gamified interactions. The approach I will take toward my analysis of Khan Academy will be consistent with Zyda's (2005) statement, “Moving toward making serious games requires human performance engineering – developing principles, processes, and procedures for their deployment ... and they must understand how to use the entertainment world's creativity with the appropriate human performance principles.” I will put the principles, processes, and procedures of Khan Academy under a magnifying glass and distill the interactive qualities that succeed in making it entertaining.

Video games are the representation of a very specific form of HCI; they are at once both an interactive system as well as an active experience that is capable of motivating learning and learning behaviors (Paras & Bizzocchi, 2005; Zyda, 2005). It is also understood that video games are a successful engagement mechanism; video gaming is a multi-billion dollar industry annually (Shaffer, Squire, Halverson & Gee, 2005; Kirriemuir & McFarlane, 2003), and in a capitalist economy that type of money means that video games are very good at successfully motivating people to interact with them (Floyd, Portnow & Siegel, 2011). Unfortunately for notions of gamified education, however, while the game industry is very good at creating entertaining video games, they do not seem to be as adept at designing entertaining educational video games (Barab, Thomas, Dodge, Carteaux & Tuzun, 2005). The result of this is a possible conflation of the guiding principles behind most video game development, and the principles that should be guiding the design
of educational video games (Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989). What is now needed in using video gaming for education is a practical map for how these two things can be integrated in order to maximize learning potential (Eck, 2006).

The current generation of children has become disengaged from traditional forms of education (Eck, 2006). Throughout this decline of engagement with education, video game designers have been successful in growing their own field and created an engagement boom (Gee, 2004). A 2009 study by Marina Papastergiou comparing the efficacy of a games-based learning approach to a non-technical approach in a high school computer science course showed that students learned more and were more motivated by the gamified curriculum. Fortunately, new technologies are enabling ever more sophisticated gaming experiences, and so the potential for the integration of gaming and learning is steadily increasing (Paras & Bizzocchi, 2005).

**The Need for a Framework**

Not every piece of curriculum can be converted into a video game using the same methods or with the same ease, and further significant challenges exist from the perspective of turning curriculum into games or with aligning existing games to current curriculum standards. There is already a basic understanding that the differences between games is reflected in the different ways that we play those games, and that different disciplines of curriculum benefit from different types of games – in addition to the inherent interactions afforded in those types of games - to
varying degrees (deWinter, Griffin, McAllister, Moeller & Ruggill, 2010; Eck, 2006; Gee, 2005). Despite possessing these basic understandings about using video games in education, there is a remarkable dearth of literature discussing either the ways that video games should be assessed in this pedagogical role, or the design elements that these games should possess in order to be successful. If we desire to be successful in the endeavor of gamifying education it will be crucially important to first be able to distinguish the nature of those games (deWinter, Griffin, McAllister, Moeller & Ruggill, 2010; Eck, 2006).

With this paper I seek to deliver a framework for evaluating the ways that games are effective so that extant games can be critically analyzed, and to better inform the would-be designers of future educationally minded video games. There are already some impressive efforts to align an expansive corpus of games to learning, but these efforts are focused on the level of the game, and not on the more atomic levels of the game design itself that inform the interaction with the user (Eck, 2006). Gamified elements manifest themselves in many different ways, and the framework to be developed will need to constrain that possibility space to a point where analysis can be meaningful, but without being complex to the point of being unusable.

Shaffer, Squire, Halverson, and Gee (2005) argue that games serve best in a simulation role, portraying the value of games as context or textuality of games, and that learning can be ideally built around that simulated experience. Simulated environments are valuable because they require of a game player a set of practical
and learned skills to be successful in that realm. Shaffer, Squire, Halverson, and Gee (2005) suggest that at some point it will be worth defining what the core set of skills for any job is so that effective simulations can be built to accommodate every vocational role. Although they make a good argument for their position concerning the use of simulated environments to promote learning, they seem to stop short of considering the possibility of games for learning beyond highly situational simulated worlds, and thus seem to restrict the potential of games for learning to a narrow range of simulations. While simulated environments are unequivocally useful for certain types of learning, this paper suggests the real importance of Shaffer, Squire, Halverson, and Gee’s (2005) work to be the acknowledgment that games are digitally interactive learning environments. In the same way that these authors make a call for enumerating the skill sets required by jobs for better game and curriculum alignment with those job skills, this paper promotes enumeration of the sets of interactions those games might have with users in support of engendering those valued learning experiences.

What I show in this paper is a systems analysis of the human-game interaction, focusing primarily on the interaction elements qua game design decisions. I will make use of Fast and Sedig’s (2011) definition of interactions, which roughly stated are those actions performed within a system taken together with the response of that system. I intentionally situate this study on the interaction level of games, since interactions with systems provide a means to simplify difficult problems, thereby allowing people to work beyond ordinary cognitive limits and thus improve basic task performance such as learning (Fast & Sedig, 2011). Rather
than focus on specific learning theories, I discuss those digital interactions that support the learning process. In particular I examine to what extent does the design of this HCI system, based on what we know from literature, provide effective interactions to motivate a person to learn that is consistent across the curriculum and the methods used.

**Explanation of Framework Elements**

This paper appeals to Fast and Sedig, and Jennifer Tidwell for guidance in developing a framework engendering a list of gamified interactions. According to Fast and Sedig (2011), a framework can be generally defined as a set of interactions and tasks. This definition is furthered within the context of this paper to be the set of game play interactions and tasks that promote learning through a process of engagement. The Fast and Sedig paper looks at and lists a set of atomic interaction techniques available to users when interacting with visual representations in a digital library. Jennifer Tidwell’s Common Ground follows the example of Christopher Alexander’s “A Pattern Language”, and explores the interaction space afforded by digital design patterns (Tidwell, 1999a). In both papers the authors lay out sets of possible interactions between users and systems by first identifying the type of interaction and then describing the action.

The objective of this paper is not to articulate an exhaustive list of interactions available within a given system, but rather to take the first bold steps toward such a list and set the foundation for future works that might make an even more ambitious attempt. While a fully enumerated list of gamified interactions, or a
pattern language, from a wide cross-section of digital learning environments and educational video games will be ideal for the purposes of improving the gamification field, what is first necessary is to show an approach to how such a list might be created.

By drawing on a framework based on pattern languages I intend to put forth a candidate for a unifying vocabulary for gamified design. The development of this vocabulary is a necessary part of creating a working framework that will have scalability in its application to other video games, and also portability allowing these analyses to go both across and between disciplines interested in this field of study (Fast & Sedig, 2011; Lombardi, 2000; Tidwell, 1999a).

In some ways this paper is similar to the Microsoft Research Games for Learning Institute white pages article “Educational game design pattern candidates” which sets out to describe a number of these gaming patterns that might facilitate education (Plass and Homer, 2009). There are a few important differences between the Plass and Homer (2009) white paper and this thesis, however. First, the use of “patterns” in this paper aligns more closely with Tidwell’s definition of the word, making note of the afforded user interactions as opposed to a set of vague properties about video games. Second, Plass and Homer do not discuss their methodology for determining and discovering the patterns they list, as I do in the subsequent sections of this paper.

The full scope of the framework will include methods, the manner in which a game is used to promote learning (Lieberman, 2010); patterns, “possible good
solutions to a common design problem within a certain context” (Tidwell, 1999a); and design elements, a specific implementation of a particular pattern.

The role of the method within this framework defines the contextual space for the patterns and design elements. Within the context of the framework the patterns will be broadly descriptive of the interaction with the user (Fast & Sedig, 2011). The design elements will much more explicitly describe specific instances of interaction techniques supporting how a person learns from a game, and will inform the types of curriculum best addressed by applying that game type (deWinter, Griffin, McAllister, Moeller & Ruggill, 2010; Keramidas, 2010).

The choice in nomenclature derives in part from the literature and also partly from my own preference to construct a descriptive metadata. The use of “methods” comes from Lieberman’s “Four ways to teach with video games” article, and relates to the way a specific game is used to motivate learning (Lieberman, 2010). “Patterns” follows customary usage in the design community, where a pattern is a general template for determining the shape of the structural elements (Tidwell, 1999a). I introduce the term “design elements” to refer to specific interaction techniques because each technique is the elemental, discrete instantiation of a particular pattern.

Each of the methods is capable of being supported through multiple patterns, and some patterns may support more than one method. Additionally, a single pattern can be instantiated by many different design elements, but each design element can belong to only a single pattern. Because of this cardinality of the
relationships between methods, patterns, and design elements a successful user-system interaction will depend on correctly identifying and using those patterns and design elements that best support those interactions within the appropriate context (Fast & Sedig, 2011).

**Framework Elements**

**Methods**

My discussion of game methods draws on Max Lieberman’s, “Four ways to teach with video games”. As the title indicates, the paper provides a taxonomic classification for the ways that video games can be used to teach, and then discusses the strengths, weaknesses, and challenges of each approach (Lieberman, 2010).

**Method 1. Games That Teach Content**

“Games that teach content” is the most straightforward of the methods. Video games used to this effect are the type most closely resembling an off-the-shelf video game, and in them the content of the video game aligns directly with some piece of curricular content. While there is evidence that this method can impel children to pursue learning after the game has ended, the meat of the learning experience occurs during gameplay, and so the success of this method relies on motivating the child to continue playing the game.

The learning by playing method that these games engender matches well with constructivism-based pedagogy, which supports a general concept of learn by doing (Lieberman, 2010; Plass and Homer, 2009). Additionally, for digital natives,
there is an affordance of being able to present learning material through a vehicle that students are very familiar with due to their similarity to conventional video games. Lieberman (2010) calls this a usage frame, which is a form of entry into educational material – so even in cases where the material is foreign to the student, the interaction with that material will at least be familiar.

Although Shaffer, Squire, Halverson, and Gee (2005) suggest that games that teach content can provide students with entry points into a field through “epistemic frames”, this actually marks a point of divergence within this game type. In a game like Operation Neptune where players solve math problems to achieve game objectives a child will be encouraged to want to learn about submarines, but solving the math challenges in the game will not necessarily encourage the child to learn about the history of algebra. A game like Oregon Trail, on the other hand, because of the nature of the content – American frontier history - provides significant inroads into cultivating an interest in learning about the American frontier; and the explorative nature of the player seeking out that knowledge is paralleled by the exploration required within the game to beat it (Lieberman, 2010).

The obvious strength of “Games that teach content” is that they provide a one to one correlation between what is being done in the game and what it is the person is trying to learn. Two examples of this are Operation Neptune and Math Blaster, where in each a player has to solve math problems in order to unlock or achieve specific game objectives.
Opportunities for this style of video game are abundant, but all face the challenge of making the educational task relevant to the game (Lieberman, 2010). One way to get around this is to create a game builder that allows you to input the material to be learned through a custom application programming interface (API). A potential weakness of the API approach is that while the questions within the game might change, the core game experience remains the same, and so little is provided by way of long-term variety. This could in turn reduce the motivational impact of the video game, although I have not yet found literature to support that idea. Another major challenge is one of scalability. To sufficiently provide enough video games for all types of content there would need to be games developed for each possible piece of curriculum content. While this is a daunting challenge, projects like GamesParentsTeachers.com (www.gamesparentsteachers.com) do attempt to provide a resource for matching games to content.

Method 2. Games as Texts

Lieberman’s (2010) second method is “Games as texts”. The predominating idea with “Games as texts” is that while there may be no direct correlation between elements in game and curricular material, the games themselves are still valuable for being able to teach students critical thinking skills, learning methodologies, or proximal epistemic ideas that have relevance or bearing on the core curricular material.

Using the example of a massively multiplayer online (MMO) game, no fewer than four literacy skills might be leveraged during a casual play session: critical
analysis, multicultural communication, collaborative writing, and reflection about the relation between in-game and real world skills (Lieberman, 2010). Games that fall under this category are often very text-heavy and require a lot of reading. In addition to the reading required inside of the game, these types of games have the potential to encourage student to do extra-curricular reading which can further develop the above mentioned literacies.

One of the clear strengths of this type of game is that it is not constrained to be content aligned, and so in that regard the development of these types of games is simpler. Since these types of games are not content aligned, however, it can be more difficult to sell the value of these types of games within a school setting than it might be for a content aligned game.

According to Shaffer, Squire, Halverson, and Gee (2005), games as texts are invaluable for creating simulated virtual worlds that permit students ample opportunity for exploration. This exploration transitions well into encouraging the student to learn more about the subject and related materials outside of the context of the game. Additionally, the tolerance of these games to permit continuation after failure can help imbue students with a form of perseverance and tenacity that synergizes very positively with traditional learning processes.

“Games as texts” shares one weakness with “Games that teach content”, which is that these games have a requisite level of video gaming literacy to be successfully played. This might be a minor point due to the pervasiveness of video gaming - currently 75% or more of children in this nation (McGonigal, 2010). Even
though children might have ready experience with games, the teachers who would be relied upon to present these games to the students very likely do not have the same depth of experience (deWinter, Griffin, McAllister, Moeller & Ruggill, 2010).

Another weakness of “Games as texts” is that though they tend to often rely on writing and textual communication, most games do not portray a level of writing on par with commensurate, grade-appropriate books.

Popular games that fit under this model include Civilizations 3 and Rise of Nations, both which explore historical modeling and figures, and Railroad Tycoon 3, which explores economic and geographical issues surrounding railroads (Shaffer, Squire, Halverson & Gee, 2005).

Method 3. Creating Games

The third method for promoting learning through video games is to have students create video games. Much of the structure of this method and many of the benefits are shared with the games as texts method, because it creates engagement between the student and a subject, usually in the form of conducting the research necessary to create or write the game. Constructivist theories of learning, which posit that learning is most effective when students construct mental models or tangible artifacts, provide the rationale for this method.

Within the realm of students making games there is a preference for mini-games because designing that type of game best allows the student to focus on the core material while marginalizing the need to learn complex technical skills, and also because it helps to ensure that the content being studied is central to the game.
For more involved games, such as role playing games, student involvement in creating games can focus strictly on developing and writing dialogue for characters.

Using game creation to teach poses some major challenges for the practicality of implementing such a system. The primary challenge is that game creation requires a much higher level of technical literacy on the part of both the teachers and the students to be successful when compared to the same amount of literacy needed to simply play a game.

These technical challenges further manifest themselves in the cost-reward ratio for using the creation of games to teach. While simpler games require less skill, effort, and time to create, they also tend to teach smaller pieces of information that do little to support higher levels of thinking (Lieberman, 2010).

Of the four methods for using games to teach, creating games is the most time expensive. Inside of a normal class day with tight time constraints on class-time, creating games simply may not be feasible. To accommodate this challenge the literature suggests that, if this method is pursued, it might best be done during a summer program or after school program where fewer time constraints exist.

Because the game creation is designed for a specific curriculum it is expected that the game should align well with that curriculum. Additionally, the very open nature of video game design means that these games could theoretically be relevant to any field or subject. Still, these benefits come at high time and technical literacy costs that will require work to mitigate in order to improve the net benefit of teaching through creating games.
Method 4. Game-Like Motivational Systems

Game-like motivational systems use game mechanics to keep players engaged with some task. Here I focus primarily on achievement systems. As of 2010 this interaction was the least explored in academic literature for its use in education, although motivational systems themselves have been a part of games and game systems for many years now (Lieberman, 2010).

In addition to the traditional achievement systems that are typically connoted with game-like motivational systems, there are a number of other forms they might take. Variable ratio reinforcement within games makes them less predictable and operates as a ludic element to keep users more engaged. Game-like motivational systems can also manifest elements of scaffolding and zone of proximal development, working to teach new skills that that are built on what students learned before, thus increasing the motivation to stay with a subject through a long arc. Including in-game tutorials and social networking elements such as robust chat and messaging features can motivate players by serving as valuable entry points and engagement points. A final motivational element is for the game to set clear goals and provide immediate feedback as players work toward those goals.

There is anecdotal evidence to support the viability of game-like motivational systems in the classroom setting. The Extra Credits (2011) video blog and an ad-hoc study by Janna Jackson that Lieberman (2010) writes about both seem to reach agreement on more than a few ideas for implementing these systems; things such as providing assignments of varying difficulty levels within the same subject to
promote continued learning in a subject beyond the required level, allowing assignments to be attempted without penalty until the student masters the exercise, creating experience point and leveling up systems that marks when students could progress to new material, and keeping track of high scores in order to encourage healthy competition.

Game-like motivational systems have one tremendous advantage when compared to the three other methods, which is that they can be wrapped around any existing pedagogical system without creating any curricular disruption. Add to that the fact they can be implemented incrementally, so that participants have the ability to adapt to the changes, and to allow missteps with the implementation to be walked back without too much loss, and these systems make a cogent argument for their viability in the classroom. The specific game-like motivational system called and achievement system – rewarding points or badges for accomplishing minor and major objectives within games – is the most cost effective variety (Zyda, 2005).

For all of the benefits there are still some challenges to overcome with implementing these systems in educational settings. These systems need to be designed and implemented in such a way as to encourage interaction by both teachers and students. Without making the achievements desirable students will not feel compelled to work toward earning them.

Implementing systems such as these also represent additional work that needs to be undertaken by teachers to monitor and track whatever facets are used. There are fortunately some examples of these systems already, such as Khan
Academy, that incorporate features to not only mitigate, but also enhance a lot of these more statistical driven elements.

**Patterns and Design Elements**

**Patterns**

Khan Academy, while not a video game, employs a number of game-like interaction elements that encourage engagement and promote learning. The intention of the site is to serve as a nexus for education by providing instructional videos on a very wide range of subjects\(^1\). To support engagement with these videos the site includes the ability to save a user profile that will track progress through curricular subjects in the form of a knowledge map, badges, and achievements.

Khan Academy leverages a number of patterns that fall predominately under the “Games that teach content” or “Games as texts” headings. One of the significant advantages of this system from the outset is that it is web-based, meaning that the entry requirements of access to a computer and a network are comparatively low to the purchase of a gaming system costing hundreds of dollars. As noted above while describing the four methods, there are challenges to designing and producing games for modern gaming systems, and so a web-accessible system is a great design decision permitting a maximum number of people the opportunity to interact with the system.

\(^1\) At the time of writing subjects include Algebra, American Civics, Pre-Algebra, Basic Arithmetic, Art History, Banking and Money, Biology, Calculus, Geometry, Chemistry, Computer Science, Cosmology and Astronomy, Economics, Differential Equations, Finance, History, Linear Algebra, Microeconomics and Macroeconomics, Organic Chemistry, Physics, Probability, Statistics, and Trigonometry.
What follows is an identification of each of the apparent interaction patterns used in Khan Academy, a description of how that pattern is used by the system in terms of the design elements that contribute to the pattern, an analysis of the design elements, and then a suggestion for how the design element might be improved or how it might be used by another system.

**Pattern 1: Serendipitous Learning**

Going to the Khan Academy site there are inviting visual elements that immediately capture the attention of visitors. Examining the videos on display quickly shows that the videos cover a range of variable subjects for new and noteworthy videos. A new user to the site will be encouraged to watch one of these in order to serve as an introduction to the site, while returning or frequent users will find that this is an opportunity to discover something new. This first pattern is serendipitous learning, and within games it often finds its expression in the form of random information on loading screens, or within context sensitive menus inside the game. Another place where this style of interaction is prominent and recognizable to a large swath of individuals is in the featured daily article of Wikipedia.org.
Figure 1: The home screen presents a rotating selection of site content.

Within the framework of the four methods this pattern of serendipitous learning most closely aligns with is Games as Context. The designers understand that these videos will not usually be what a resource-driven visitor is coming to the site for, but by presenting them there is an appeal made to the exploration-minded visitor who might use this as an entry-point to discover something new, and in doing so make known new realms of subject material for the user. Alternatively, these serendipitous interactions can also serve to reinforce epistemic elements through increasing the number of encounters a person has with that piece of information.

This pattern for interaction is especially valuable for educational games that contain many pieces of content or information that might not be discovered in a casual play-through, and so are most relevant to “Games as texts” games than the
other methods. “Games as content” games are very typically linear in nature and will not offer many opportunities to diverge from a pre-defined path, but even so these serendipitous pathways can still be used at loading screens, or any static screen, to foster an interaction that encourage users to explore related topics that are proximal to the featured content.

One way that Khan Academy could further improve the serendipitous learning that might take place would be to include an option to pick a random video. Interactive elements that rely on chance are the very definition of serendipity, and can remove the cognitive burden of a person forced to pick a video at random.

Yet another way the improvement of serendipitous learning could be accomplished would be to present users with a trivia question each day. Users would be encouraged to find the answer to the question by perusing the library of videos available at the site and watching one that contained the answer. This could be further incentivized by offering points or badges for correctly answering these questions.

**Pattern 2: In-Game Tutorial**

Situated in the top-right of the home screen is an “About” option which links to information detailing the various features of the site and describes how to interact with those features. In-game tutorials are a meta-interaction pattern within game design because they are an interaction feature describing the mechanics of other possible interactions within the game. They are often important as a starting point
for all of the user’s experiences with a system, and often provide an entry level of knowledge required to begin interacting with the system (Plass & Homer, 2009).

Figure 2: The “About” section is a guide to using the site.

In designing an educational game that encourages continued participation from players, in-game tutorials serve as a persistent point of interaction with the system that users of the system can turn to when they might feel lost or confused.

A necessary feature for in-game tutorials to be effective is that they be easy to access from within any other gaming task or workflow. In this regard Khan Academy succeeds by placing the “About” item in a top banner bar that is persistent across each of the site pages.
While the implementation of the in-game tutorial in Khan Academy succeeds on the point of being readily available from within any site interaction, it could be improved in two ways. First, the tutorial should open in parallel with the activity that the user is engaged in. Currently the feature breaks play flow by navigating away from the active page, and from here relies on the user's own abilities to return to the activity. To the credit of Khan Academy, the system does maintain task integrity by remembering how much experience a user had accumulated on a specific task when returning to that task.

The second improvement to be made would be the incorporation of context-sensitive help elements. Context-sensitive help is an adaptive design pattern that takes into account what the user is currently doing inside of the game and offers help information relevant to the available or afforded tasks at that moment. Context-sensitive help is especially engaging since it promotes the notion that the system cares about and is knowledgeable about what a user does.

**Pattern 3: Social Platform**

The third interaction pattern used by khanacademy.org is the inclusion of social elements. A person can log in with either their Gmail (gmail.com) or facebook (facebook.com) identity. This promotes the social nature of the site and provides frameworks for scorecards, competition, and sharing. The inclusion of social elements in games contributes strongly to the enjoyment that people experience while playing those games (Plass & Homer, 2009).
Modern video games include social elements using a number of methods. Notable methods include massively multiplayer online games which create game spaces where many player avatars exist and interact in order to complete common goals, online message boards such as one mentioned by Kurt Squire that grew around the Civilization 3 gaming community, and the XBOX Live gaming community that allows users to interact with each other through means of voice chat, video chat, text messages, rate other gamers, and view and compare game statistics with other gamers.

From an interaction standpoint the important of social elements is that they permit player to be active rather than passive participants in a community that is either real, such as the case with the message board that grew outside of the game, or virtual, as is the case within most MMOs (Shaffer, Squire, Halverson & Gee, 2005). By bringing us together with other people these interactions foster the development of social skills, and can help to teach players how to be a member of a community (Shaffer, Squire, Halverson & Gee, 2005).

Khan Academy delivers a number of socially motivated interaction elements that support interaction both on and about the site. One of the especially nice community interactions are the comment areas beneath the videos. These comment areas encourage users to post questions about the video, or even answer other users’ questions that have been posted about the video. Questions and answers can be voted on by other site users, and depending on the number of those responses
the site makes certain rewards available, thus creating a mini-game to engage users in dialogue with each other about the site content.

Figure 3: Comment area beneath a video.

Although Khan Academy already provides a design element that creates persistent identities for users of the site including a limited and pre-defined set of
avatars, it could be improved by going one step further to allow users to create custom avatars. Allowing a user to have control over their digital identity through the use of an avatar very strongly encourages engagement and participation with digital systems (Barab, Thomas, Dodge, Carteaux & Tuzun, 2005). This could be further capitalized upon by allowing users to “friend” other users in order to quickly compare usage statistics and achievements, or see what other people are working on.

![User profile with blue leaf avatar and custom badge display](image)

**Figure 4**: User profile with blue leaf avatar and custom badge display

**Pattern 4: Scaffolding**

Khan Academy features a Knowledge Map that can be accessed by clicking on the Practice button from the home page. The Knowledge Map presents a number of math exercises up to a certain difficulty in a very structured manner, with easier and more foundational items being placed at the top, and descending through more complex topics toward the bottom. Although a user can choose to complete any section at any time, encountering difficulty within a certain area is generally an indication that work should be completed at a level higher on the map first.
Figure 5: Visual of the Knowledge Map showing multiple scaffolding elements.

The pattern represented by this interaction design is scaffolding. Although it might help to conceive of the map in an upside down manner where the more foundational elements are the bottom, even on this inverted scaffold the proximal elements occurring higher on the map support the ideas of the lower elements. The importance of scaffolding is that it reinforces mastery of lower levels and lower difficulties before progression to more complex tasks. Within the context of games this helps to ensure a smooth progression through the process of acquiring and mastering new tasks, and mitigates the likelihood of attrition due to presenting the player with a task that feels impossible to complete.

Another form of scaffolding that Khan Academy uses on the Knowledge Map is to suggest possible next exercises based on which exercises have already been completed. On a negative note, however, the Knowledge Map performs
questionably in this regard as it will suggest basic, foundational exercises even after more complex exercises requiring mastery of those foundational exercises have been successfully completed.

Scaffolding concepts also appear within the specific exercises available from the Knowledge Map in the form of recommending related videos to the current practice topic. Providing this information affords the user the ability to easily return to a more foundational element if they feel overwhelmed by trying to complete the current task, or if some component of the task is unclear. For a user who is not a tyro this is particularly nice because it means that movement along the knowledge map is not unidirectional, and so a person with an advanced set of knowledge is not forced to work tediously through very simple tasks in order to reach a point of appropriate challenge.

![Order of operations](image)

*Figure 6*: Videos related to the “Order of operations” practice item.

Based on this analysis it is clear that scaffolding patterns require a concept of knowledge organization, including how different topics relate to one another, as well as which topics need to be mastered before proceeding to other topics. This can present special challenges for subjects that become widely accessible after mastering only a few concepts, which could bring the user to a topic that had a
hundred branches to suggested material, or for subjects that contain many disjointed pieces, which might lead to a lot of disconnected knowledge map islands that quickly strand users.

**Pattern 5: Videos**

Within video games cut-scenes are expository design elements, and provide a rich vehicle for demonstrating narrative or even other techniques in the form of a visual tutorial. Cut-scenes can serve the purposes of narrative, tutorial, or reward, and can even operate in all capacities at once. Although often passive in nature, cut-scenes are still capable of engaging users.

Videos are a core presentation device of Khan Academy, and there is a multitude of ways to access them. Within the context of the practice area the video is a tutorial element. If a person engaged with the site is having particular difficulty on any one learning element the video describing how to progress is within easy reach.
From an interaction and engagement perspective the problem represented by videos is that they are a very passive element. The extent of a user’s interaction with a video is often limited to just playing, pausing, rewinding, and fast-forwarding. A defining aspect of video games is that players can consequentially alter the events that occur within the game. Modern games have attempted to provide a solution to this problem in the form of quick time events (QTE), sequences interspersed into cinematic sections requiring player input to successfully complete the cinematic sequence, but even QTEs are regularly vilified by game reviewers as unnecessary and the product of lazy design.
There are no easy answers for how to design more interactive cut-scenes and in-game video, and this is a problem that video games themselves seem to be struggling with. Some possible solutions could look to the example set by choose-your-own-adventure books and support multiple pathways to different win conditions. A design decision like this could encourage the user to interact with the cut-scene multiple times in order to explore those different pathways, and be particularly useful in curriculum built around understanding consequential action. Cut-scenes inside of a gamified learning system could also model themselves more closely off of discussion style classrooms, where the user might be able to interact with a video to influence the direction of the material presented by the video. Either of these solutions is empowering to users, and both highlight interactive affordances for the user.

**Pattern 6: Clear Objectives**

In the same way that in-game tutorials are an important representation of a starting point within games, clear objective setting is important for defining milestones and endpoints in games.

Within the Goals section the user can choose one of two pre-defined goals, either complete five videos, five exercises, or create a custom goal where the user defines some combination of videos and exercises totaling up to ten. Making use of these provides clear, achievable goals.
Figure 8: Goal setting in the form of self-assigned “quests”.

One real opportunity that could be explored and is mentioned in the Extra Credits video blog would be to integrate the concept of quests and then combine the questing and social elements to create group objectives. Evidence of this type of interaction is very common, and often a core mechanic, within massively multiplayer online games. Providing this type of interaction can easily scale the motivational and social forces promoting engagement to an entire classroom (Floyd, Portnow & Theus, 2011).

Pattern 7: Immediate Feedback/Measured Progression

The final, and one of the most outstanding patterns on the Khan Academy site, is immediate feedback or measured progression. As a rule all provided feedback should be relevant to the tasks that the user is completing (Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989). There are no fewer than four design elements
related to this pattern within Khan Academy, including an experience bar, badges, scoring and the visual representation of the Knowledge Map.

**Design Elements**

Design elements are specific instances of the patterns mentioned above. Where patterns represent a possible, generalizable solution, design elements are the precise form that the pattern takes within the given scenario. Each of the design elements that I discuss below all fall under the seventh pattern, “Immediate feedback/Measured progression.” While there are many more design elements within even just Khan Academy, the ones I choose to show here exist to show the completion of the methodology from methods, to patterns, and finally to design elements.

**Design Element: Experience**

Within games experience is a non-arbitrary and quantifiable measure of progression toward some goal. Designers can use experience as a way to form a requirement for the certain number of times a task must be done before the user can progress, such as number of experience-yielding monsters needed to be killed before leveling up in a role-playing game. The accumulation of experience usually results in gaining a level, and so it works as a mechanism to break a larger goal down into a certain number of much smaller goals.

Of the different design elements discussed in this paper Khan Academy executes on Experience the weakest. Within the practice section of the site answering questions correctly will earn experience points and increase the
experience bar by some amount. Answering questions incorrectly will cause the user to lose experience points, although they cannot drop below zero experience, and decrease the experience bar by some amount. In order to increase the experience bar within the practice section it is necessary to correctly answer ten questions in a row. Where the experience system fails in Khan Academy is that there is no pay-off for successfully filling the bar other than a message indicating that the user is ready to progress to the next exercise.

Figure 9: Answering questions correctly fills the experience bar.

Khan Academy’s experience system misses a really good opportunity to tie in with scaling/leveling up. Once again, filling up the experience bar by getting 10 correct responses in a row only completes the exercise. It would be more engaging to the user if filling it up would still permit moving forward, but also grant a level up with more difficult problems in the same subject.

Another improvement that could be made using experience and leveling up would be to pair it with a token economy and avatars so that players can use the
currency earned through playing to purchase in-game items such as clothing or gear to equip their Avatar, or to unlock additional game modes, such as one that challenged players to correctly answer as many questions as possible in one minute. Offering these types of challenge modes can provide motivation to interact and engage with a topic for long after a player becomes proficient at it.

**Design Element: Badges/Achievements**

Badges and achievements are both built around a collecting behavior that is innate to people and finds roots going back to early humanity (Sotamaa, 2009). In general achievements amount to a form of “gaming capital” and exist as a secondary reward system (Sotamaa, 2009). An underlying strength with achievements is that they have the ability to promote new and different ways to interact with an established game environment, and can add layers of depth to any game experience (Floyd, Portnow & Theus, 2011; Sotamaa, 2009).

For the value they have the potential to provide, badges and achievements elements also share a few common flaws. From a measurability standpoint, achievements are limited by what the game is able to quantitatively measure or perceive (Sotamaa, 2009). Other users might focus so intently on collecting badges that they fail to understand the meaning of the tasks they complete in order to get that badge (Floyd, Portnow & Theus, 2011). And finally, designers might choose to include meaningless badges that fail to encourage the desired user interaction (Floyd, Portnow & Theus, 2011). The ability on the site to set goals for the user to
achieve badges available through topics on the Knowledge Map, for instance, might encourage the user to play to achieve the badge rather than play to learn.

![Image of badges earned]

**Figure 10:** An example of framing achievements as end objectives.

Despite these challenges, Khan Academy manages to succeed very well in a pattern interaction between the social elements and badges. Some badges on the site are earned by participating in the game community, either by posting questions about the videos or answers to other users’ questions, and this is a terrific interaction for two reasons. One, the system is using one motivating behavior to encourage users to engage in a different motivating behavior, and so there is a cumulative effect to the motivational interaction. Two, these badges are worthwhile because they engender reflection on a particular topic in order to generate a question, or can even potentially encourage a player to explore a new topic in order to discover the answer to another user’s question.
From an interaction standpoint, achievements have the ability to encourage reflective interaction on the part of the player by motivating them to approach a solution from a novel angle. The ability to see what achievements have not yet been earned can provide the player with clues about how to earn that achievement, and through that interaction heighten the re-playability of the game.

**Design Element: Scoring**

Khan Academy tracks a user’s cumulative score for their lifetime on the site. Points are earned by completing exercises, earning certain badges, or watching videos. Scoring systems allow users to measure themselves against either objective or subjective comparisons, and competition for the highest score can promote continued interaction with the system in order to continue earning points (Sotamaa, 2009).

The problem with the use of scoring in Khan Academy is that the score does not necessarily reflect mastery or skill, and so comparisons of score have no basis. There is a possible scenario that permits a high score to be gained through simply playing all of the videos without watching them or learning anything from them. While this type of play would be an unintended abuse of the system, the possibility for it happening undermines many of the motivational elements of scoring systems.
One improvement to the scoring system that has already been mentioned in this paper is the addition of an alternative practice mode or mini-game that challenges players to correctly answer as many questions possible in a minute, and then scores players based on how many correct responses they provide in that minute. A similar challenge could be a practice mode that scales in challenge as correct answers are given, and then scores based on the number of consecutive correct answers a player can achieve. In both of these cases, the scoring system is based on active interactions rather than passive interactions, and so the ability to achieve higher scores has value.

Design Element: Knowledge Map

Where the Knowledge Map supports scaffolding in the user-system interaction, the visual representation of the Knowledge Map lends itself to be more of a feedback mechanism. The Knowledge Map utilizes Google Maps (maps.google.com) technology to create a map of learning, with evident pathways of knowledge. A simple glance at the map can show a user’s position, the path that the user took to reach that point, and provide visual cues indicating possible future paths. The map is valuable because a user can identify a place on the map they would like to reach, chart a course to that point, and then as the user progresses track their progress toward that goal at any given moment.
Figure 12: Wide view of the Knowledge Map with colored topics.

The interaction with the Knowledge Map functions similarly to Google Maps. Users can zoom in on the map focus on a small subset of subjects that are adjacent, and therefore more closely related, to the user’s current position on the map, or they can zoom out to gain a more ecumenical perspective on where they are in the scheme of the entire Knowledge Map. These interaction mechanics are especially
helpful since the map is large and requires both place finding and navigation. To move around on the map a standard grasp and drag mechanic is used, and this interaction is afforded by the icon changing to a hand when moved over the map element.

As users interact with icons on the Knowledge Map that represent discrete topics, those icons change color. According to the legend in the top-right corner of the Knowledge Map these colors and representations are green for suggested items, blue for mastered items, orange for items to be reviewed, and grey for items that have not yet been interacted with. Color is also prevalent in the line coloring connecting the knowledge items on the Knowledge Map as users move through the content. This use of color is a nice design element because users viewing the map can quickly differentiate completed areas on the map from unexplored areas, in addition to those topics that may not have been visited in a while and could benefit from additional review; however the use of green and blue should be reconsidered for users of the site who may be colorblind.

Where the Knowledge Map could be improved would be to grow the use of it on the site. I was personally disappointed to discover that knowledge maps did not exist for the range of subjects available on the site, because I think that it is a very valuable didactic. There would likely be challenges with applying this concept to every topic, but success at creating these additional interactions would be rewarded with presenting a better experience for users across all topics.
Within the current implementation of the Knowledge Map one interaction that could benefit from improvement is the zoom feature on the map. The only interaction available to the user to support zooming is the Zoom icon in the top left of the map. Users interacting with the Knowledge Map who have prior experience with Google Maps might have an expectation that the scroll wheel on the mouse would also be able to control the zooming, since similar forms usually connote similar interactions, but they would be incorrect. By allowing the mouse wheel to control the zooming functionality the site would interact in a more intuitive manner, and meet the usage expectations of more users.

**Conclusions**

The big question about gamification is no longer a matter of whether gamification will occur, but when (Gee, 2003). Applying video game design to digital learning systems is a very real strategy for improving education, but it is still a field that needs a lot of work if it is to reach its full potential (Floyd, Portnow & Theus, 2011; Kirriemuir & McFarlane, 2003). This paper has attempted to make inroads toward addressing one leg of that by providing a working start to a pattern language for gamified interactions.

One author cautions that creating educational games is very difficult because of the aggregate difficulty levels involved with both creating games and creating educational experiences. Khan Academy shows that this need not necessarily be a one or the other approach by creating an educational system that makes novel use of game elements. There are already opportunities to apply gamified concepts to a
wide range of existing material on a small and doable level that can lead to real gains in the classroom. One way that these patterns might be further improved upon would be with case studies exploring the ease or difficulty of implementing each design.

This paper represents only a small part of the work that has yet to be done in this field. One of the first things to accomplish will be to fully enumerate all of the interaction design elements that contribute to and form the core of gamified interactions. The methodology laid out in this paper shows promise for its application on a wider scale, and the application of this methodology to Khan Academy as a proof of concept has demonstrated what future game analyses should focus on in order to propel this conversation forward. When future game candidates are considered for analysis they should represent a wide range of games in order to show the widest range of possible design interactions. This conversation need not be limited to only forthcoming video games, either, but can also turn an eye backward and use the knowledge gained from research into this area to improve existing games.

At the level of the specific design elements, future studies should try to determine which design elements have the most appeal to the widest range of users. Design elements that function exceptionally well for a wide range of users could be applied broadly as core pattern designs in all games. Alternatively, design interactions that are less effective should be identified so that they might be improved upon or weeded out of use entirely.
Additionally, it will be worth performing analyses of interactivity based on Bartle’s taxonomy of the four types of players; the killers, the achievers, the explorers, and the socializers (Sotamaa, 2009). Being able to understand and identify the type of player engaged with learning games will present opportunities to develop adaptive gamification elements that will be able to adjust on an individual basis to maximize the potential interactivity with that player.

In parting I want to leave readers with the message that the quality of the delivery method does not equal the quality of the end result. The best possible interactions still need to be supported by well-wrought content in order for educational gaming to reach an optimally desirable result. If designers intend to be successful at creating true game-like learning experiences they will need to remember that games are played because they are fun, and making the game experience too much like work will be self-defeatist. It is already a given that people learn from video games, the question is rather what designers are intentionally or inadvertently teaching video game players. Gamification may just be the most important thing that the video game industry every does (Floyd, Portnow & Siegel, 2011), and Jane McGonigal goes so far as to state that once game designers can fully leverage the motivational and learning potential of games, then not only will games be a useful vehicle for teaching, but will also then be capable of solving the world’s problems (McGonigal, 2010).
References


### Appendix A: Glossary of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>HCI</td>
<td>Human-computer Interaction</td>
</tr>
<tr>
<td>MMO</td>
<td>Massively Multi-player Online [game]</td>
</tr>
<tr>
<td>QTE</td>
<td>Quick Time Event</td>
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