Failure's Paradoxical Relation to Success:
What Games Can Teach Us that the Academy Misses

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Abstract: This paper explores the relation of chaos to pattern in Wolfram's Rule 30 en route to exploring the essential role failure plays in the success of a game. Tentative pattern identified in the face of game chaos encourages the player to postulate new patterns that aid in dealing with failure. Identification of a usable pattern provides cognitive traction for a player attempting to overcome odds, discern relationships, vanquish menacing opponents, and consolidate winning strategies that temporarily stave off disaster. In a good game, there is just enough pattern for a good player to identify and thus win. In a great game with only evanescent pattern, a great player sustains temporary success by learning from failure. Games can therefore teach higher education a paradoxical lesson it currently poorly understands--namely, that failure has an essential role to play in academic success.

Keywords: Wolfram Rule 30, pattern, academic failure, failure in games, degenerate strategy, player failure and game success

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1. Introduction

A paradox that haunts the academic community can be illumined by and perhaps even redressed significantly by game play. Notably, academic failure has such undesirable connotations that, ironically, the academy has largely failed to understand how important failure is to success. Comparatively little has been written about the positive dimensions of academic failure at the collegiate level and even less has been written about the positive role failure can play in genuine education and life experience more generally. In a word, in a rush to embrace mono-dimensional excellence, the academic enterprise has been taken in by the siren song of success and has eschewed the deepening, enriching experiences of failure. Perhaps no area of human experience can serve as a better corrective to this venerable misunderstanding than games, game play, and the essential role of player failure in great games.

Essential role of failure in both great games and in education generally

The purpose of this paper is to explore the critical role of failure for significant games so that we can redeem failure as a necessary experience for significant education. In a good game, the prospect of failure provides the incentive for learning the game. In a great game, as in larger human challenges, the player strives heroically to stave off chaos by seizing pattern and imposing order when chaotic disaster appears to be not only imminent but finally insuperable. As a result, failure is an essential ingredient in profound success, a lesson which games can teach the academic enterprise.

Staving off chaos for a time

The three major parts of this paper include, first, a discussion of the literature related to conventional views of academic failure; second, an exploration of Wolfram's celebrated Rule 30 whose importance to computer science is well known but whose relevance to understanding game pattern recognition has not been highlighted; and, third, the experience of a grant-funded experimental course, "Game Programming on the Web," which attempts to identify the mechanics of how failure is important to successful games. Concluding sections explore degenerate strategies and the paradoxical relationship of player failure to game success.

Rule 30 CA

2. Conventional Views of Academic Failure

Conventional views of academic failure are pervasive. For example, Rafoth (2004) articulates what at first looks like a perfectly sensible view of academic failure:

Preventing academic failure means that we, as a society, are much more likely to produce individuals who feel confident about their ability to contribute to the common good ... Thus the prevention of academic failure should be a primary concern for any society.

Following in the venerable trail blazed by Pitcher and Blaushild (1970), we read a litany of reasons why failure is academically irredeemable, most of which echo the conventional (and often defensible) reasons why individual failure has such undesirable social ramifications. Notably, there is no attempt to discern whether failure might have some redeemable qualities and might, in fact, be among our most important, instructive experiences. Salau (2014), writing from an African perspective, more readily recognizes that students should "handle failure so as to get the best out of it," but the work's brevity precludes a substantive discussion. Davis (2013) astutely observes that elite educational institutions stand furthest from "successful failures" and has some useful generalizations about failure, but does not mention how instructive games can be in this regard.

How failure might be a part of complex real-world challenges

More generally, the academy has been better at identifying causes of failure—notably, how failure might be avoided—than in coming to a considered view of how failure can be important in education. For example, the University of Alabama's "Causes of Failure in College" identifies ten deficiencies in students that lead to failure rather than attempting to identify how failure might be an inexorable part of complex tasks in real-world challenges, that collegiate education ought to anticipate and perhaps even simulate. Kravosky (2004) does better in suggesting that any study of success that does not include the role of failure "tends to create a misleading—if not entirely wrong—picture of what it takes to succeed" and we get some hints from Smith (2015) of how failure might be redeemed, but little more.

Buddhism in Cupertino

We do better recalling a justly celebrated Stanford Commencement address with more than 20 million YouTube views. Steve Jobs' story is well known but perennially instructive. He dropped out of school, eventually started Apple Computer, then was fired from his own company, "a very public failure." But he claims in the address that "getting fired from Apple was the best thing that could have ever happened to me." This public failure was an essential ingredient in perhaps the most storied, successful business career in tech history. Jobs spoke eloquently of the inexorable failure of death that gets us out of the "trap of thinking we have something to lose." Evidently, Jobs understood better than his distinguished audience just how important failure is to success.

3. Cellular Automata, Chaos and Complexity

Cellular automata (CA) have been studied extensively since work of von Neumann (1966). A two-dimensional CA will have a primed top row and calculated successive rows, which are determined recursively by applying the CA rule to each row. Like a conventional computer, elementary cellular automata are digital and binary, with each cell taking either a 0 or a 1, determined by the CA rule. As a result, the evolution of a CA is determined by a table specifying the state a given cell will take in the next generation. Figure 1 illustrates this, using Rule 30.

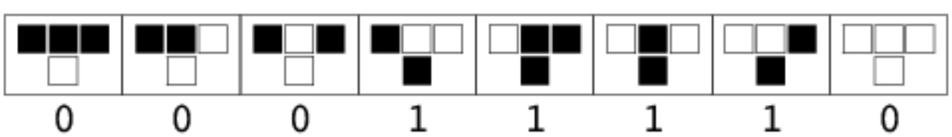


Figure 1: CA cells take either a 0 or a 1 in an elementary CA such as Rule 30. There are 2^3 possible binary states comprising its rule, since each place has one of two values, depending on the state of the three previous cells. This simple table computes the entire run of the CA, which is extraordinarily complex.

For example, when the three preceding cells are black (the first cell on the left), the rule specifies the new cell should be white. When the three preceding are black, black, white, the new cell is also white. But when the three preceding are black, white, white (the fourth cell from the left), the new cell is assigned 1 or black.

There are four classes total, according to Wolfram's (1994) scheme. Class 1 runs and then dies out. Class 2 is orderly with a repeating pattern. Class 3 may have some local pattern but has no overall, identifiable pattern. Class 4 (see Fig. 2) contains both Class 2 and Class 3 elements and is pertinent to the psychology of game play as well as countless other complex adaptive systems.

4 classes of CA:
(1) dies out;
(2) repeats;
(3) chaotic;
(4) complex

Figure 2: Class 4 CA: Complex Pattern. Wolfram Rule 22 generates this complex CA (rows 0 to 1530). We seem to have a perfectly predictable pattern but closer examination shows that each iteration of the structure differs from earlier ones and the difference is unpredictable. Nonetheless, we have some cognitive traction and some ways to characterize it non-trivially.

No generalizable way to predict chaotic behavior in Class 4 just as there is no generalizable way to predict the course of a great game.

Good games are class 4 (complex), but the chaotic component is always there since 4 is a combination of 2 (order) and 3 (chaos)

Important for discerning some of the implications for game play, the connection between nonlinearity and computational irreducibility is critical since there evidently is no generalizable way to predict the behavior of Class 3 systems. We cannot expect such a method or formula to emerge; in fact, that is one way to define a great game. A great game, in other words, cannot be "gamed." While there will be occasional identifiable patterns in a Class 3 CA, which can provide important cognitive traction (Freeman 1992), there is not the sustained pattern necessary to get a sense of the CA more generally. That is, there are no Rule 30 cheat sheets. It remains an evanescent enigma, closed to formal analysis and any broader understanding. Effective cheat sheets for games, in fact, are evidence that a game could be richer, deeper, more complex, more like life, and more like a good Class 3 CA.

Closed to formal analysis and any broader understanding

4. Rule 30 and the Specious Search for Enduring Pattern

Perhaps the most studied and even celebrated Wolfram (2002) CA, aside from Rule 110 and its proven Turing completeness, is Rule 30. Rule 30 is usually classified as a Class 3 system, which means it is fundamentally chaotic. As illustrated earlier in Fig. 2, Rule 30 takes its name from its binary rule, "00011110," which is 30 decimal. The general consensus is that Rule 30 is chaotic but this is not a probable result and Rule 30 runs tease us with the repeated appearance of pattern. That is what makes it tantalizing and pertinent to the psychology of games.

Teasing us with the appearance of pattern, just as a great game does

Rule 30 generates a complex, almost certainly chaotic pattern of indefinite length. Wolfram (2002, 15) believes it repeats, but with a period of "a billion billion times the age of the universe." It is impossible, of course, to test this hypothesis. Accordingly, it is reasonable to conclude it is effectively infinite in size—that is, it is impossible to state categorically that there is no pattern that repeats. But for our purposes, it does not matter. What matters is that the search for a repeated patterns comes close—but never, so far as we know, gets an exact match. Rule 30 beckons, like a siren song from Greek mythology, it tantalizes, but resists our attempts to characterize it by means of a pattern.

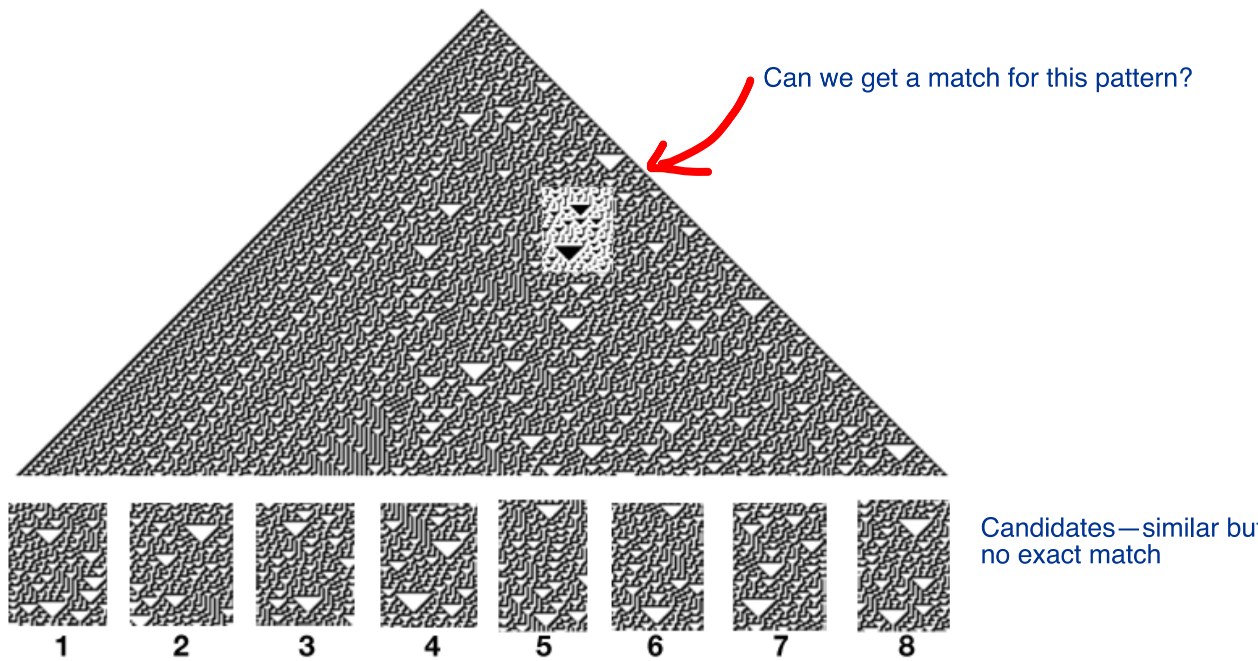


Figure 3: Search for Pattern in Rule 30. Wolfram Rule 30 generates a CA with pattern on both sides but these are artifacts and wash out when the CA is wrapped cylindrically. Here one pattern is highlighted and a search is made for matches in later sections. Rule 30 tantalizes but never yields, as far as we know, a match of two sets of patterns. Section 2 comes the closest but a moment's study reveals it too fails to match.

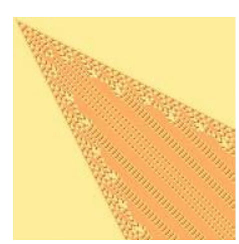
As illustrated in Figure 3, Capture 1 with two larger triangles looks like a possibility for a match, but it fails, of course, because the triangles are differently aligned. Even the smaller triangles do not match. So there is a casual-glance similarity, but its solicitation turns out to be specious. Capture 2 has the angle right but the sizes wrong. As well, it has a "grill" not present in the original. Closer inspection startles us with the many ways similarity can vary from identicality.

This too is the way a great game will fool us—we think we have it figured out but it proves us wrong at critical turns with humiliating defeats. That's why we love it!

Exercises in applied similarity

Rule 30's allure has kept researchers looking for decades (Gage, Laub, and McCarry 2001; Martin 2008). Capture 3 has the right angle of the two triangles but it is mirror imaged. The smaller triangles come close to matching but, once again, we are disappointed. The closer we look, the more the initial hope for similarity fades. Capture 4 has the right angle of the triangles but, alas, they are too large. The other triangles are an exercise in applied dissimilarity. Capture 5 has about the right angle, but the triangles are too far apart. And it is much too busy with a host of medium-sized triangles that are not present in the original. Each comparison reveals at best a weak fractal relationship: similar but different and the differences accumulate the more we look. Initially, it looks promising, but closer inspection disappoints. Self-similarity, we repeatedly learn, is not identicality.

Capture 6 also has the right angle and the relative sizes of the principal triangles seem promising, but they are too far apart. The other triangles excite with their similarity but there is still no match. Capture 7 almost immediately fails for multiple reasons, despite specious initial impressions. Capture 8 has the right angle but the wrong size for the upper triangle. We learn repeatedly how many ways a pixel arrangement can be similar but not identical.



This is one reason why AI is unlikely to work: subtle pattern recognition requires judgment that evidently beyond the capacity of calculation to emulate. Artificial intelligence is neither flexible not creative (see Cantwell Smith, 2019 and Larson 2021)

Pattern recognition is largely precocious and embodied

So this evidence suggests we are are unlikely to find a pattern. But, notably, each search failure can still have significant instructive value (Jiang, et al. 2015). When we become experienced at coming close to matches, we learn a generalized sense—not easily captured in a formula—of what to look for in pattern. Pattern recognition is a largely preconscious, embodied skill (Margolis 1990) that every game player must cultivate. But pattern questions are just as important in academic work, business, and political leadership. When is some evidence of pattern enough, given limited resources? How is an economic recovery like and not like a previous one? Every attempt at real-world pattern recognition must inevitably fail, but as we learn from failed attempts at pattern recognition, we sometimes can identify limited patterns with temporary utility.

Temporary utility may be all we can get from epidemiology — the bugs keep evolving

The parallel between Rule 30 and great games is therefore instructive and warrants more research. Some important questions are: What is a pattern? What is the psychology of patterns that are similar but not identical? If Rule 30 is computationally irreducible, and the evidence suggests it is, to what extent is pattern similarity computable? Are all great games similarly computationally irreducible?

Is pattern similarity a computable function? What does “pattern” mean?

5. Programming to Learn from Failure in “Pirates & Navy”

HTML Canvas element to the rescue.

In a senior-level course funded for the last two years by an Innovation Fund grant at Augsburg College, Minneapolis, MN, USA, CSC 495, “Game Programming on the Web,” one student assignment is the game “Pirates & Navy,” as illustrated in Fig. 4. The game is principally written in JavaScript and enables the complex graphics supported by HTML5’s Canvas element. Canvas supports scriptable rendering of 2d images that constantly refreshes a low-tech bitmap but, when done well, supports an immersive, compelling graphics experience for the player.

Low tech but effective bit-map

Figure 4: Programming for Failure. The “Pirates & Navy” assignment in CSC 495 instructs students to write the game so that it has the usual roster of perils, such as pirates, sea monsters and hurricanes, but has mechanics so that the player can learn from “failed” encounters.

As a result, since games are an exceptional way to learn programming, students learn a great deal about JavaScript HTML5 Canvas, and game design. But they learn a lesson far more compelling—and much less common in the academy more generally—when they learn to program the game so that the player can learn from being swallowed by the sea monster or being sunk by pirates hiding behind a fast-moving storm. Namely, they confront directly

Steve Jobs' question of how we can learn from failure. The assignment calls on them to build into the player experience of the game the possibility and the necessity of learning from failure. They confront daunting questions such as, "What is failure?" "How might an experience of failure turn out to be instructive?" and, "What does the failing player need to look for in the failure so that it can be a learning experience?" The parallel to searching for pattern in Rule 30 becomes obvious.

Relevance of psychology to game design

In thinking through how to program the game so that the player can learn from failure, I believe they learn how to watch their experience more generally so they can identify sometimes implicit dimensions of failure that can be even more instructive than facilely acclaimed success. Such learning involves identifying patterns that endure for a time but, like those in Rule 30, inevitably fail if we count on them being permanent. One astute programmer suggested, "Players need to look more closely for dimensions of a failure that might disclose how to do better the next time and programmers need to make it possible for the player to learn from failure. The player should not see failure as defeat but as a complex riddle to be unravelled, in preparation for the next, more complex challenge." Like a complexity theorist perusing a Rule 30 run, players and programmers need to become better at identifying the ephemeral differences between genuine repetition in pattern and the appearance of repeated pattern.

Moreover, the course required them to think through their game mechanics so that failure can facilitate learning rather than engender psychological defeat. In a word, a great game does not mean avoiding failure, as the academy often imagines, but confronting failure as perhaps the best way to learn. More than the academy, games call the question of the meaning of failure (Juul, 2013), whether it can be viewed positively, and how it ought to be risked routinely. One student programmer asked me, "Do faculty also attempt to identify how failure in a conventional course can lead to learning in a way similar to how games should be structured?" Speaking from my own experience only, the only response I could marshall was, "We are so geared to looking for success and disowning failure, we don't think through it productively."

This is our chief academic challenge and in fact the challenge in an interesting job career

People who are risk averse are not likely to blaze many new trails. Jobs was a profound risk taker. So is Zuckerberg

In conventional academic settings, that is usually how we see failure. As a result, we don't teach students to learn from failure and generally the academic system is structured most to encourage risk-averse behavior. Indeed, we have not only created a generation of risk-averse students (Buonanno and Pozzoli 2007) who see failure to be avoided at all costs, we are creating millions of risk-averse graduates.

Metaverse

6. Degenerate Strategies in Games and Risk-Averse Academic Study

A degenerate strategy is a way of playing a game that exploits an unintentional design weakness so that it becomes easier for the player to win. Degenerate strategies do not involve rule violations but they prevent the game from being experienced in the manner intended by the game designer. They shortcut the game so that it is not experienced in the way intended by the designer.

Students in CSC 495 were typically appalled when they discovered a degenerate strategy for the game they had written since the discovery of such a strategy not only meant they were guilty of a design error; more importantly, it meant that their respect for the game they had written plummeted. But I was surprised by how often they looked for such strategies in their own games. It turns out that players hunt relentlessly for degenerate strategies but degrade their estimation of a game when they find them—winning with a degenerate strategy generates contempt for the game.

We may find the parallel with collegiate education disconcerting. Students either explicitly or unconsciously often employ degenerate educational strategies. A great game cannot be gamed by degenerate strategies but evidently (Winch 2016) much of the academy can be gamed. This can mean obvious degenerate strategies such as petitioning for credit for less rigorous prior work or it can take the form of risk-averse behavior such as avoiding more challenging classes so failure is not even risked. In fact, one way to view grade inflation is that it reflects the

A great game cannot be gamed by degenerate strategies—a great university education should likewise not be gamble so the experience is shortchanged. Grade inflation is a reflection of a degenerate strategy of risk aversion

The creative destruction of the economy guarantees there will be failures. What counts is how we respond to them. Great games can be instructive in these terms.

degenerate strategy of risk aversion. Failure avoidance in students is exactly analogous to degenerate strategies in game play and we should wonder about the ramifications for the educational enterprise and how well it prepares students for inevitable career failures. We may not be preparing many future Steve Jobses for the creative destruction—and massive risks—of the modern, computationally laced, global economy.

7. The Paradox of Player Failure and Game Success

Interest in serious games, of course, has accelerated dramatically in recent years, especially in the academy (Berg 2009). That much is widely known. What is less well known is how dramatically interest in "failure studies" has accompanied academic study of games and how this research can be put to productive use.

Juxtaposition of pleasure and pain in a great game is instructive

The paradox of player failure and game success is that an engaging game must tantalize the player with the slender possibility of success but, like Rule 30, resist it at every turn. To put it another way, the juxtaposition of pleasure with pain must be much like the relation of Class 2 order with Class 3 pain, in the "edge of chaos" described by complexity theorists. The search for pattern matches in Rule 30, against the backdrop of knowing how it allures but always disappoints, parallels the search for success in a game even as the player knows that failure is never far away and, for the best games, that it is inexorable. It is the inexorability of failure that contextualizes and enriches the intense pleasure of temporary success.

A momentary stay against confusion is the best we can hope for

The paradox is illustrated in hearing a player exhort, "I hate this game, this game is completely unfair!" as the player considers throwing the console through the window. Only if the exasperation is comprehensive, however, can the pleasure in temporary success be deep. Failure must embroider the ephemeral chance for success if deep pleasure is to develop. As Frost (1939) wrote, "It begins in delight, it inclines to the impulse ... it runs a course of lucky events, and ends in a clarification of life, not necessarily in great clarification ... but in a momentary stay against confusion." Success in a rich game that parallels life, like an exploration in Rule 30, is delightful even as we recognize that all we can achieve is a "momentary stay against confusion." Success in a video game is a momentary stay against the confusion of chaos even as success in life is a momentary stay against death.

But what does the prospect, even likelihood, of player failure entail for the paradoxical success of the game itself? When we are likely to lose but want desperately to win, it binds a player to a game in a way that easy success never can. As Sylvester (2013) argues, when we lose in a game, we are responsible for the loss more than a reader of a play witnessing the death of a beloved character. Failure in games highlights the inadequacy of the player in the starkest terms. Failure is not only experienced as real, it is personal. It is often obvious for all to see. The significance of the failure is measured objectively and often brandished with chartreuse numbers against a tenebrous background.

The paradox is even deeper. As Juul (2013) points out, speaking of himself as a player, "I dislike failing in games, but I dislike not failing even more." Generally, in other areas of human activity, we strive to avoid failing, but the likelihood or even inevitability of failure is a necessary condition for the pleasure of games. Like the necessary proximity of order and chaos in a Class 4 CA, order and chaos need to be closely juxtaposed for a game to be psychologically compelling.

The pedestrian view of video games is that they are trivial exercises in fleeting excitation, that they aim to produce juvenile "fun." Juul's thesis is that this is not only shallow but fundamentally mistakes the point of a great game. We need to be empirical about this—facial and vocal expressions of players immersed in a sophisticated game tell a different story than the pedestrian view just mentioned. It may be a facile truism that people are motivated by success, but game players are most exercised by anxiety-arousing immersion in the overwhelming likelihood of failure and ignominious defeat. Players grimace, groan, howl and hurl expletives. The pleasure emerges in the grim prospects unfolding on screen.

There is some parallel, Juul suggests, among theatre, film and video games in that tragedy is a necessary ingredient. Aristotle (1997), of course, argues that catharsis is the aim of great theatre, and a conventional understanding of games is that they are like theatre and film in this regard. But Juul takes exception to this comparison—something finally more interesting is transpiring in games. Remarkably, gamers want to experience what they dislike the most. Games don't purge pre-existing anxiety and hostility; instead—and this is the heart of Juul's thesis—they are designed most of all to create and sustain them.

Some game examples warrant comment. Recently, one of the hottest single-player games was "Flappy Bird," a dauntingly difficult game involving piloting a bird through narrow gaps. Like games dating to classics such as Tetris or Pac-Man, there is no way to win. Success is measured by staving off failure, by staying alive as long as possible. Flappy Bird is so challenging that a typical game often has the duration of a ride on a bucking bronco. Players loved it. As another example, "Super Meat Boy" was intentionally designed to be less forgiving than "Super Mario," with the result that an early death is more likely. It received high praise from a variety of critics such as Bramwell (2010), who comments that "at times it is viciously difficult." How far we are from conventional academic practice in such games.

8. Conclusion and Outlook

The paradox of player failure and game success is that an engaging game must tantalize the player with the slender possibility of success but, like the forlorn search for pattern in Rule 30, resist it at every critical turn. The determined search for pattern in a game occurs even though the player knows that failure is never far away and, for the deepest games, that it is inexorable. It is the inexorability of failure that contextualizes and enriches the intense pleasure of temporary success, what the poet Robert Frost called a "momentary stay against confusion."

Gamers thus have a more sophisticated understanding of the crucial role of failure than professional academics. The sociology of academic failure is so toxic, in fact, that it exacerbates the demoralization and embarrassment that counterproductively attach to failure. Instead of recoiling or attaching sometimes irremediable stigma to failure, we ought to be teaching students how to learn from failure. Alas, as Winch (2014) has observed, "failure might be a great teacher, but it is also a cryptic one." It is time for the game community to highlight the essential role of failure for education so that failure will be less cryptic, better understood, and more fully embraced for the great teacher it can be. Making failure a less cryptic teacher, as a result, warrants a major research effort.

Games can thus teach higher education a paradoxical lesson it currently poorly understands--namely, that failure has an essential role to play in academic success.

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