

SKETCHVENTOR

Evolving Ideations by Design

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INTRODUCTION:

“In an abandoned pub a group of new Tessera recruits sit around a table engrossed in a game of cards. Throughout its centuries of existence, the Tessera has honed the creativity and innovative thinking of its members through this rite of passage. Over a few rounds of gameplay, you start to pick up a pattern: one machine, one verb. What would the Internet look like in the Stone Age? How could one expand the Telegraph? Could Wi-Fi be modified for an evil purpose? You set to work, remixing technology past and present with nothing more than a pencil, some paper, a deck of cards, and your imagination.”

In this paper, we detail the design evolution of *Sketchventor*, an original card game whose goal is to scaffold and promote players’ ideation and innovation skills. The card game is featured as part of *The Tessera*, an Alternate Reality Game funded by the National Science Foundation (NSF Awards 132378 & 1323306) that launched in January 2017. A gothic ghost story, *The Tessera* engages players with the history of computing by having them interact with famous persona—including Ada Lovelace and Charles Babbage—who influenced the development of information technologies. As a transmedia experience, *The Tessera* has an online component at <http://thetessera.org>; a real

world component at The Computer History Museum in Mountain View, California; and an artifactual component in the form of *The Tessera* card deck (see Figure 1). In this paper, we focus on the analog version of *Sketchventor*, one of two games that can be played with the card deck (shown in Figure 1). *Sketchventor*'s print-and-play version can be found at <https://goo.gl/riQjWJ>, which contains instructions for the game, and a link to printable card files.

Within the storyworld of *The Tessera*, teen players acquire and practice the skills and dispositions related to computational and design thinking. Importantly, *The Tessera* encourages youth who may not initially think of themselves as scientists, inventors, or designers to begin to imagine themselves as such. By introducing them to innovative thinking techniques drawn from the research literature on the psychology of creativity, *Sketchventor* helps players gain confidence in their own creativity and explore the process of creative ideation (Eberle, 1972; Rouke, 1988). In this paper, we report on the design evolution of the mechanics used in *Sketchventor*. We consider the game's development by closely examining two play sessions:

- An early play-testing session with an intergenerational group of players, and
- a later play session with teens in a design-based research study (Sandoval & Bell, 2004) structured to evaluate the learning potential of the game.

An examination of *Sketchventor*'s evolution—including its participatory design processes—provides new insights into the design of ideation games more generally.



Figure 1. Sketchventor “invention” cards arrayed around the “verb” cards.

GAMEPLAY AND MECHANICS:

Sketchventor is a game of creative ideation, where 3-6 players sketch and pitch ideas for new inventions inspired by rethinking famous inventions. A round begins when a judge selects an “invention” card and a “verb” card (see Figure 2), which together create the round’s “theme.” Players have about 4 minutes to sketch their invention and then 30 seconds to verbally describe (i.e. pitch) their invention. Sketches can include drawings, arrows, and explanatory text. The judge then gives awards in the form of “superlatives” by identifying the sketch they believe was “most innovative”, “most useful”, and “funniest.” Players determine the number of rounds, but typically each player gets to serve as judge at least once. An example is provided in Figure 3.

Alternative rules are provided for a less competitive game, wherein the role of judge is eliminated and each player provides

a superlative to another player. Additionally, a “wildcard” superlative can be used, which can be any adjective that describes a certain aspect of another player’s invention (e.g., “most dystopian”).

Inventions:

- Science, **Microscope** **Genetic Engineering**
- Technology, **Light Bulb** **Smart Phone**
- Engineering, **Telegraph** **Airplane**
- Arts and Humanities, **Cinema** **Printing Press**
- Mathematics, **Abacus** **Computer Programming**

Verbs:

- Exaggerate:**
Amplify part of your invention.
- Adapt:**
Transform your invention for another purpose.
- Reverse:**
Switch a sequence/function of your invention to its opposite.
- Eliminate:**
Remove a piece or function of your invention.
- Combine:**
Merge two inventions together (draw two cards).
- Shrink:**
Simplify or minimize a part of your invention.
- Villify:**
Modify your invention for a nefarious purpose.
- Heroize:**
Modify your invention for a heroic purpose.
- Anachronize:**
Imagine your invention in an earlier time period.
- Futurize:**
Upgrade or improve some aspect of your invention.

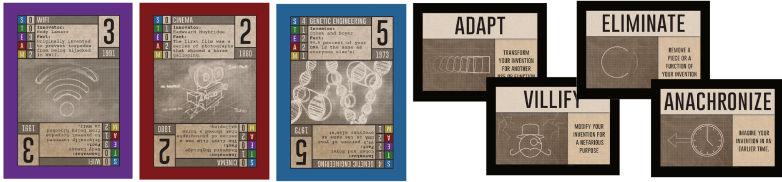


Figure 2. Some invention cards, and all verb cards, with graphic examples.

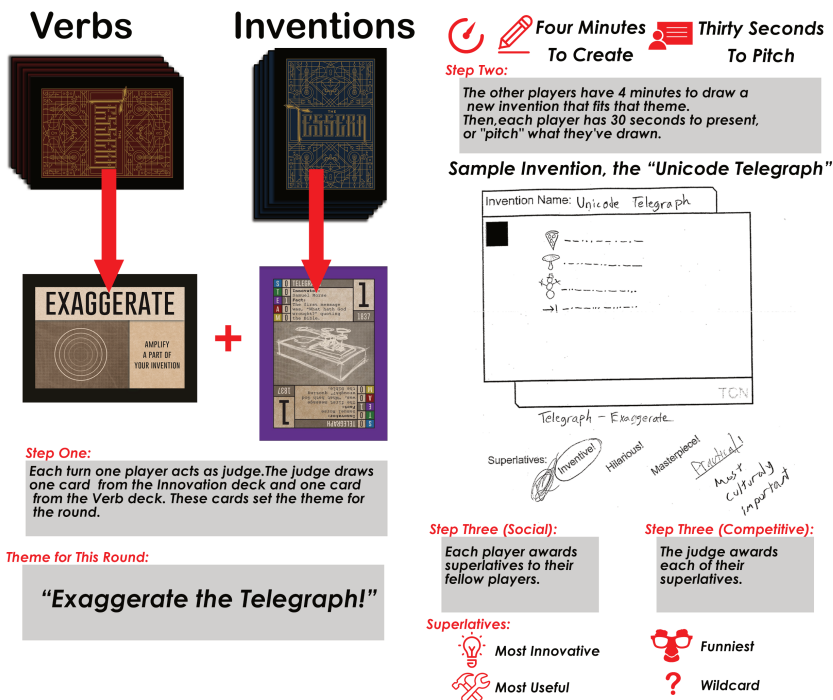


Figure 3. Rules of Sketchventor using "Exaggerate the Telegraph" as an example theme.

LEARNING CONTEXT AND BACKGROUND:

Our design philosophy is centered on the notion of activating interests in the fields of computing, engineering, and design. We use *activation* in the sense of aligning our players with a set of dispositions (i.e., attitudes, beliefs, values), practices, and content knowledge that empower them to approach future science and engineering experiences with confidence and enthusiasm (Dorph, Cannady & Schunn, 2016). We were also motivated by recent evidence that creative thinking skills have been on the decline in the United States since 1990 (Kim, 2011), even while educators, policy makers, and government leaders worldwide have acknowledged a need to facilitate creativity in education (Shaheen, 2010). *Sketchventor's* design process was specifically

situated within a larger research effort to promote computational and creative design thinking.

The germ of the idea of *Sketchventor* emerged in a preliminary form from a suggestion of Author 1, who combined two existing genres of tabletop game: social games, such as *Apples to Apples* and *Cards Against Humanity*, as well as drawing games, such as *Pictionary*. Originally, a player drew three invention cards and incorporated at least one element from each into a sketched invention. In terms of generative mechanics, that initial approach drew on the idea of combinatory card games from *Apples to Apples* (e.g. the act of having to think on one's feet in order to respond to a prompt given a limited set of options in one's hand), alongside the limited creative constraints imposed by drawing within a time limit (e.g. representing an abstract concept through drawing within the span of a minute timer).

In a follow-on design team meeting, we brainstormed ways that we might scaffold the innovation process beyond the 2-3 invention cards that players could draw in a round. There was concern that our initial open-ended prompt might be daunting to our target teen audience. We settled on the idea of using a set of verbs that “players could use as design trigger mechanisms to create their new innovations”, such as “Combine, Subtract, Superimpose, Repeat, Animate, Contradict, etc.” (team email, Sept 2015). We were inspired by ideation techniques from the psychology of innovative thinking known as Synectics and SCAMPER (Gordon, 1961; Roukes, 1988, Eberle, 1972). In Synectics, designers apply “trigger mechanisms” (e.g., verbs such as *distort* and *change scale*) to an existing idea or problem so that “ordinary perceptions are turned into extraordinary ones” (Roukes, 1988:13). Similarly, SCAMPER asks innovators to combine existing ideas with verbs (**S**ubstitute, **C**ombine, **A**djust, **M**odify, **P**ut to other uses, **E**liminate, **R**everse) to create something new (Eberle, 1972), and has been shown to increase the quality of children's inventions (Rule et al., 2009). We aimed

to embed these ideation prompts into Sketchventor's play to spark design thinking and creative dispositions in teen players.

We also drew upon several previous games for inspiration which helped us to differentiate and expand on the rules of our own game. As mentioned previously, the initial idea for the game came out of both social (sometimes called 'party') games, such as *Apples to Apples*. In terms of mechanics, we reviewed other drawing games such as the classic *Pictionary* to help us think through player interaction with game materials.

As we worked through the design process we discovered the game *Disruptus*, an award winning game by Funnybone Toys (2010), which also has players draw new inventions inspired by combining a verb (create; improve; transform; disrupt) and a specific item (e.g., stoplight, football, vending machine, street). Verbs are selected with a dice, and items are everyday objects. Though similar, our focus on historical inventions and ideas, incorporation of different verbs, and integration of different award structures collectively serve to differentiate the game. Still, we believe our findings are relevant to *Disruptus* and similar games.

Jesse Schell's (2014) *Deck of Lenses* uses the card/deck form factor to inspire game developers to consider important elements of the design process. Each card in the deck presents a different 'lens' for considering game design – for example, the lens of "Physical Interface" provides the instruction that "the player has a physical Interaction with your game ... Use this lens to be sure that your physical interface is well suited to your game by asking ... questions [such as] How does this map the actions in the game world? Can the mapping be more direct?" (ibid). The random nature of the deck is presented as being a means to consider unexpected or particularly difficult aspects of game design.

Sketchventor's design reinforces four major dispositions (from

ITSE, 2011) important to our work: the verb and innovation combination presents an open-ended problem (“tolerance for ambiguity” and “open-ended problems”). Players must also draw on scientific and technical knowledge of inventions alongside creative skills such as drawing; and they must deploy convincing argumentation in order to devise and then present a solution to that problem (“confidence in dealing with complexity” and “ability to communicate and work with others”).

DESIGNING *SKETCHVENTOR* THROUGH PLAY:

Many design decisions that define *Sketchventor* emerged and were confirmed from an iterative design process with players, and thus were derived largely through play. We integrated traditional methods such as beta-testing (Fullerton, 2004; Hammer et al., n.d.), with participatory design and co-design techniques (Druin, 1999; Muller, 2008; Schuler & Namioka, 1993).

Two play sessions comprise our close reading of *Sketchventor* gameplay: (1) an intergenerational playtest conducted during the design phase of *Sketchventor*, and (2) a data collection session with teen participants from the research phase of the game.

There were several major design ‘moves’ over the course of our initial development process, which drew on three major sources:

- **The Design Team:** included the authors of this paper. We brought our own personal experience as players and designers of games, as well as theoretical perspectives on learning and identity development. We often participated as players of the game in the playtesting and cooperative design sessions.
- **Intergenerational Playtesters:** were drawn from diverse settings and perspectives (e.g. players at a board game cafe, students in an undergraduate class on Digital Literature). Our intergenerational playtesters engaged in gameplay sessions

that reflected more traditional beta testing environments (Fullerton, 2004; Hammer et al., n.d.).

- **Teen Design Partners:** from our target demographics helped develop several core components of Sketchventor by sharing their unique perspectives as players (e.g. teen design partners were the original inspiration for the later idea of ‘superlatives’).

Figure 4, below, gives a chronological summary of how each of these sources contributed to the eventual rules and form factor of *Sketchventor*.

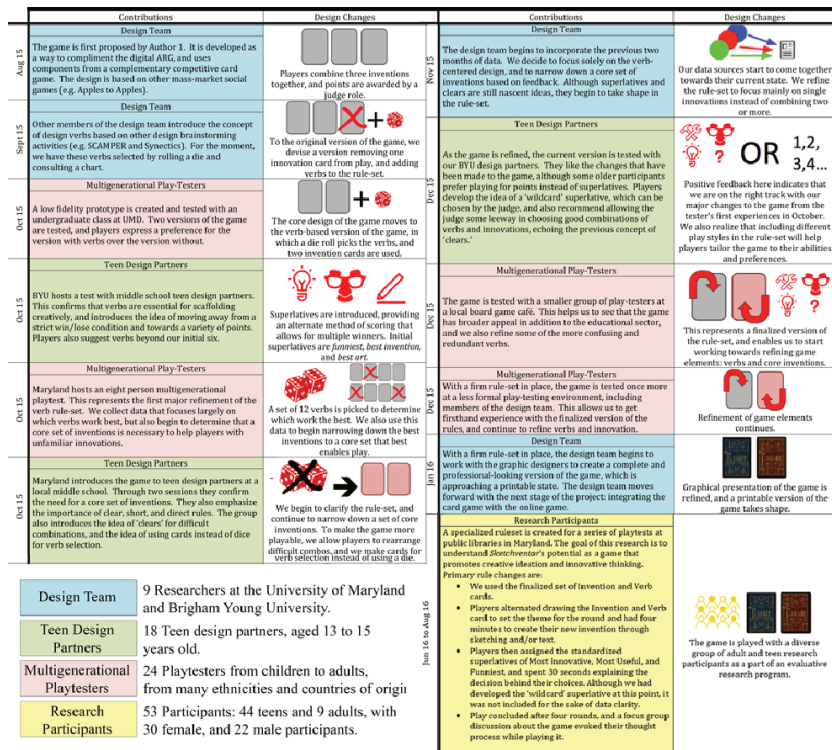


Figure 4. The design process of *Sketchventor*. Blue represents the design team, red represents multigenerational playtesters, green represents teen design partners, and the yellow represents *Sketchventor* played as part of a research study conducted in summer of 2016.

CLOSE READING ONE: MULTIGENERATIONAL PLAYTEST, OCTOBER 2015

Throughout our design process we conducted 11 total playtesting sessions that contributed to *Sketchventor's* current rendition. Our first close reading focuses on the third design session, held in October, 2015, which drew an intergenerational group of eight players who ranged in age from 12 to 43 including one middle school aged participant, one undergraduate, four graduate students, and two working adults. The rules of the game for this session had several differences from the final product described above:

- We had not yet picked our core set of inventions.
- A six-sided die was used instead of verb cards, with a reference list of available verbs.
- We used both the point and the superlative variants for this playtest.
- We used two verb lists with one representing ideas taken from Synectics and SCAMPER (Eberle, 1972; Gordon, 1961; Rouke, 1988), and the other containing additional verbs derived from suggestions during previous playtesting.

After a brief introduction, players were divided randomly into groups for play-testing. There were two sessions per group, with each session having two distinct themes unique to that group.

Refining the Card Decks

From field notes recorded by the design team during the session, it became clear that some inventions caused problems for players along two dimensions of gameplay: first, understanding the design and function of the invention, and second, being able to manipulate that invention in a way suitable for the verb card. In one group, the judge for the round set a theme involving the ENIAC computer (Electronic General-purpose Computer – the

first mainframe computer system). Instead of proceeding directly into the sketching portion of the round, players had to discuss what the ENIAC was, its component parts, and how it fit with the verb. We noted that this disrupted the flow of play, and took players out of the experience of creating a new invention. We explored this idea in the large-group discussion, described in Figure 5.

Author 1: So you guys ... pulled out [meaning removed from play]... the ENIAC ...

Playtester 2: Yeah, it was too obscure. I mean ...

Author 1: So... it's also an actual invention, so was it hard because it's like an actual historical--

Playtester 2: Yeah, you either know what it is or you don't.

[There is general agreement -- one playtester asks if "ENIAC was a tube-based computer, right?"]

Author 1: You also pulled out space travel -- space voyages...

Playtester 1: Which could have worked with others things but not with what we had.

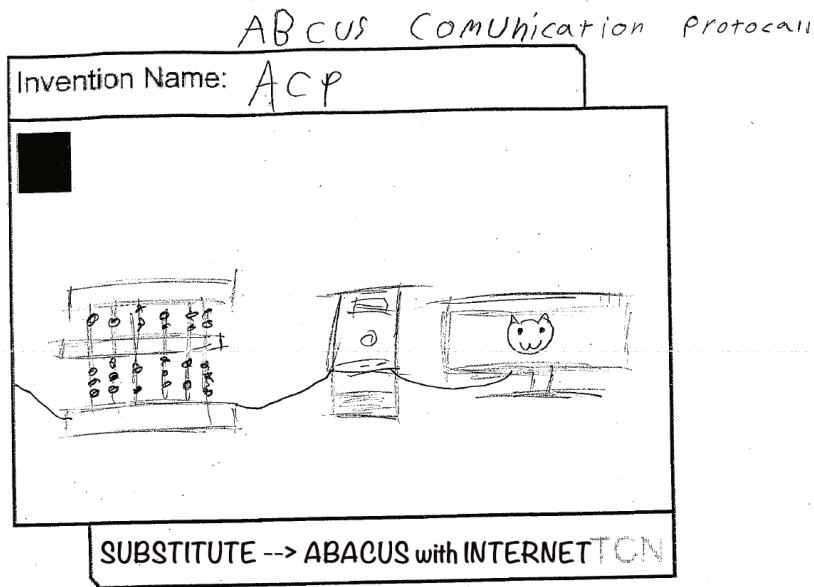
Playtester 3: Yeah, the verb we had was combine... and to combine an object with space travel... I mean, it's just not doable ...[laughter]...

Author 1: So because they weren't in the same class ... it was hard?

Playtester 5: What did you try to combine with space travel again?

Playtester 4: I think it was originally the abacus.

Playtester 3: And so it would be like some guy walking around with an abacus going ... I'm going to Jupiter ... [laughter].



Superlatives: Inventive! Hilarious! Masterpiece!
My job Cray!

Figure 5. Playtesters discuss difficulty with “Space Travel” and “Combine”, along with one player’s combination of *The Abacus* and *The Internet*.

What we learned through play, in the case above and other playtests, was that some inventions have certain properties that make them easier to elaborate upon. Inventions needed to have a certain degree of currency in contemporary culture, even if they are archaic or obsolete (e.g. the Abacus is a defunct technology, but nonetheless continues to circulate with some familiarity in the larger cultural discourse).. Generic items tend to work better than specific historical artifacts (e.g. The Computer instead of ENIAC). Items work best when they are a complete invention, not a component piece of another invention (e.g. the transistor). Finally, abstract concepts are difficult to work with in the game’s

format (e.g. rethinking ideas such as Space Travel, or Science Fiction), but can work for advanced players.

Furthermore, throughout our playtest discussion, we found that while some existing inventions are difficult, they still generate interesting and fun circumstances for gameplay. An example can be seen in the above transcription: although the ENIAC was perceived as a tricky invention to work with, players still engaged in a generative conversation as they discuss what the ENIAC was, its functions, and its history. Since the invention cards are also used in a second game (*The Tessera Inventors Card Game*) we flagged certain inventions that fit with the criteria described above as a set of core inventions. The core set is used by players new to *Sketchventor*, with a prompt in the instructions to mix in more challenging inventions as they gain experience with its signature ideation game mechanic.

Similarly, our playtesters for this session helped to confirm an idea that had cropped up previously: a need to both refine and scaffold the verbs in our game. For this playtest session, we offered two verb lists, one that was more formal and inspired by codified innovation exercises such as Synectics (Roukes, 1988; Gordon, 1961), and SCAMPER (Eberle, 1972), as well as a more informal list, cultivated from ideas provided through previous playtest sessions. In this playtest, we observed that verbs needed to:

- suggest a concrete action that the player can take,
- be discrete from one another (e.g. an original verb of *modify* was deemed as too similar to other verbs, such as *adapt*.)
- include short annotations (which lead to the eventual design of our verb cards with short, text descriptions, as well as illustrative iconography).

During this session, we also noticed that the use of a die for verb

generation (cross referenced against a list), was cumbersome and took players out of the game. Middle school players confirmed this idea in a later playtest when they asked for verb cards as a replacement.

Refining Rewards and Win Conditions

Through our participants' play, we began to understand the importance of offering multiple end-game conditions for rounds: more formalized points, and less formalized superlatives. Importantly, our playtesters pointed out a popular feature from our design inspirations, especially *Apples to Apples*: the idea of play itself being pleasurable, and not necessarily needing a firm end-game condition encoded by the ruleset.

This playtest was our first formal trial of an idea developed earlier in the month, with eight teen design partners. They formed one group of 4 girls and one group with 2 girls and 2 boys. After each round, we let each player "vote" on the most innovative design, best drawn design, and most useful design. After several rounds of play, the all-girls team always assured that each person received exactly one award. With some prompting, they explained that they liked to do this as a way of being "fair" and they didn't feel like there should be a "winner". In contrast, the mixed-gender group did have a winner (i.e., someone who received the most superlative "votes"), as well as "losers" who did not receive any superlative for the session. One of the girls in that group, confidentially after gameplay, explained that playing was fun, but she disliked the game because her inventions hadn't "won" and didn't receive any superlatives over several rounds.

Consequently, for this test of *Sketchventor*, we had each group play one round with typical point assignments, and another round using our superlatives: *most inventive*, *most hilarious*, and *masterpiece*. There wasn't a consensus about which end-game was

necessarily better, but players agreed that having a choice was optimal, as in Figure 6.

Author 3: So [after] 5 or 6 rounds, what would be the endgame, I mean, who would be the winner? Would you prefer superlatives, or points, or...

[There is cross-talk, with some players saying points, and others saying superlatives.]

Author 3: So, we just got both answers... [laughter].

Playtester 2: I would, almost consider having it be an optional thing [general agreement from whole table]. 'Cuz some people just wanna screw around, and some people just wanna be like, "I have the most points, I win."

Playtester3: ... you know, declaring a winner... I mean, that was cool Like, "I won one round, that's awesome..." But, at the same point, there wasn't -- there wasn't really an end goal... I think we all had fun doing -- **playing** -- this game -- as opposed to -- y'know, "I won."

Playtester 6: Right. You think of points...with like, skills-based games...or something, Right...? I was just saying, like maybe you could do like an Apples-to-Apples thing. Like you can get points for humor, too. I mean, somebody can choose it **not** because it makes the most sense...

Playtester 3: So multiple categories for point-assignment. So like, best idea points, but also like, weirdest, or...

[There is general agreement from the whole table.]

Figure 6. Playtesters discuss scoring.

From this conversation, and from the experience of watching our players engage with our game, we derived the idea that our win conditions worked best as modifiable elements of the rules. Instead of presenting one or the other, we instead moved towards both superlatives and points being options for play, that are customizable for each individual instantiation of the game.

CLOSE READING TWO: TEEN PLAYTEST, AUGUST 2016

This second close reading was drawn from a research session with 3 teens and a teen librarian held in August 2016. The teens, two girls and one boy, were all entering 11th grade and were lead members of the teen library program. Player 1 in particular represented herself as being “really into engineering.”

Playing With Decomposition And Recombination

In the first round, players drew the “Eliminate” and “Airplane”

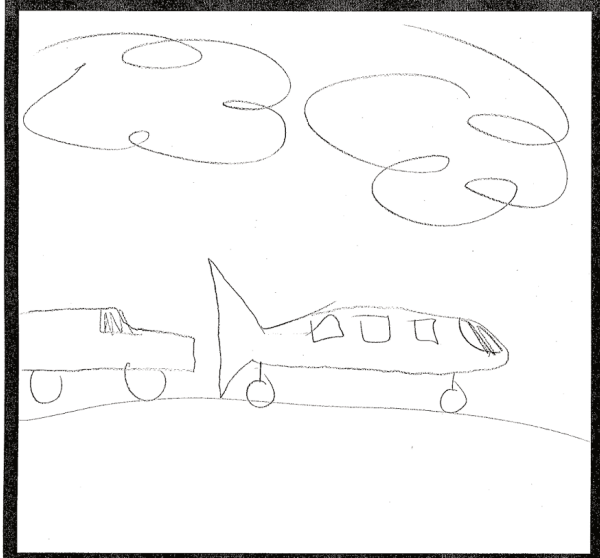
cards. Player 3 made a list on the bottom of his sheet, one column labeled “Functions” and the other labeled “Parts”, which he used to break down the airplane into its various components to consider which he wanted to eliminate. This process of decomposition, a distinct computational thinking skill, allowed him to generate a new invention he christened the “Airplane Car,” which eliminated wings and the function of flight. Player 3’s design stood out as the only player to take away the core function of flight, and his fellow players recognized that element of his drawing through superlatives.

The focus group discussion revealed that all players considered decomposition one of the vital skills for playing *Sketchventor* successfully, as shown in Figure 7:

1

Invention Card: Airplane
Verb Card: Eliminate

Innovation Name: Airplane Car



Airplane

Functions
~~flight~~
transportation

parts
wheels
~~wing~~
engine

PLAYER 3

Player 2: *I think you need to think very abstractly, because you have a lot of, um, inhibitions when considering things such as the airplane. You know it has one single function which is to fly people around, and so you have to think more beyond its...primary function and like, consider the solutions to each of the...eliminating the parts.*

Author 3: *What other thinking skills do you think you need to be good at this game?*

Player 4: *Analytical skills and being able to take apart the verb and the innovation that you got, the card, and being able to twist it around and do different things, so that analysis skills are important.*

Figure 7. Player 3's Innovation Sheet for the Airplane + Eliminate round, featuring a brainstorming list of functions and parts of an airplane in the bottom left-hand corner. Players 2 and 4 discuss decomposing inventions and verbs.

The emphasis on decomposition reinforced our design decision to focus on inventions with the optimal balance between specificity and genericity so that players could easily identify the component parts and functions. Even though Player 2 said she had difficulty looking beyond the primary function of an airplane, she could still identify it and think about other ways that function could be accomplished. Both she and Player 1 approached the design task from the lens of what problems might arise with the existing invention. Player 2 disliked the way that plane engines can be hazardous to birds in flight, and so chose to eliminate them, but did not specify how else the plane might be powered. Player 1 replaced the wings with solar panels as an alternative energy source, and took the additional step to replace the seating with luxury massage chairs to address the discomfort of flying, “a personal problem I have with planes.”

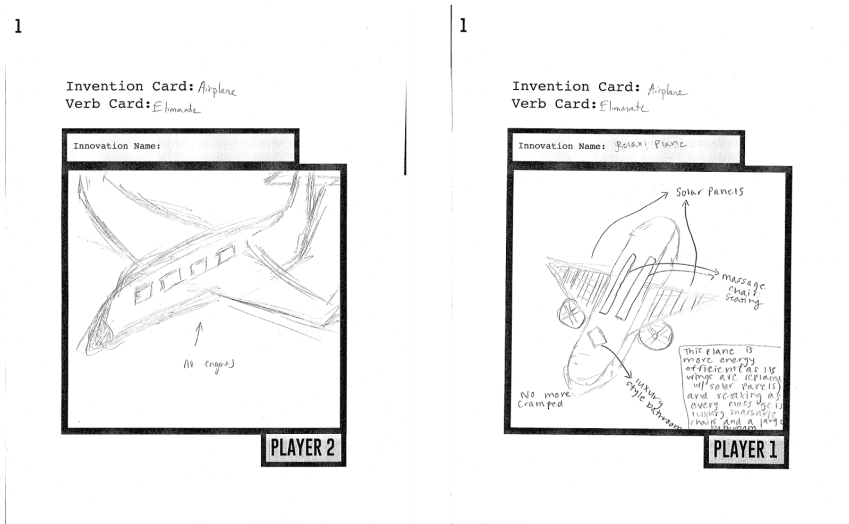


Figure 8. The Innovation Sheets for Players 2 & 3 for the Airplane + Eliminate round.

“Something besides what it normally does”: Ideating from the Everyday to the Novel

Framing *Sketchventor* as a problem-solution design task allowed these players to identify ways into creativity that stemmed from the familiar and made the task relevant to their personal needs and desires. While at first glance finding solutions to problems in existing inventions seems to privilege functionality, the verb card does not insist on replacement of the eliminated part, leading to inventions such as Player 2’s airplane that flies without engines, much like a glider.

While invention familiarity could aide players, it sometimes posed a level of challenge. The second round asked players to “Adapt” “Wi-Fi”, causing Player 3 to remark during the drawing round, “This is hard!” In the focus group discussion, the players elaborated on why they found this task so difficult, show in Figure 9:

Player 4: I enjoyed the Wi-Fi one because that was a little bit... you're taking something kind of standard and thinking, how in the world can I rework this? So taking... an invention that you really don't think you can rework again, um, pushes your limits a little bit.

Player 3: Yeah, I agree with that. Like, it was something that you don't really think about it because, oh, you think wi-fi is just an Internet connection, but now it's like, okay, now change wi-fi to make it do something else besides just be Internet, and so I thought that was pretty neat you had to make it into something else.

Author 3: And that made you feel creative?

Player 3: Yeah, because you had to think of something else besides what it normally does.

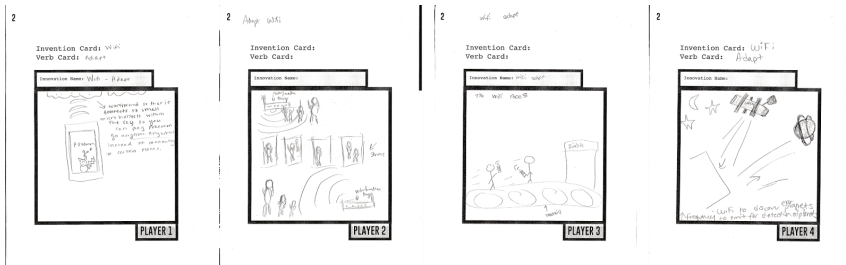


Figure 9. Players discuss “Adapt Wi-Fi”, and their Innovation Sheets for that round.

Player 1 took the same problem-solution approach as she had in the first round to create what she called a “Wifi-Adapt”, a sort of universal Wi-Fi that “connects to micro-hotspots in the sky so you can play Pokémon Go anytime anywhere instead of connecting in certain places.” Thinking purposefully, Player 4 imagined using an amplified Wi-Fi emitted by satellites to help discover exoplanets in the far reaches of the solar system. Player 2 took what she described as a “metaphorical approach”, where people can be “sucked into Wi-Fi and meet up in the servers”, which is how they can access websites and get immersed into virtual reality worlds. Player 3 again took a humorous approach in creating “Wi-fi Races” in which people have individual treadmills whose speeds correlate with the speed of their Wi-Fi connection: “the worst connection will always lose.”

Similar to the airplane example, Wi-Fi has one salient function for these teen players: connecting them to the Internet. However, the inventions that resulted from their Adapt + Wi-fi

combination were significantly more varied than that for Eliminate + Airplane, even though they found the task harder. One of the reasons is that *adapt* is a broader verb than *eliminate* (indeed, it's a superordinate verb that might be said to encompass several of the other verbs). Another reason is that Wi-Fi is intangible in comparison to the materiality of the airplane, and our teen players likely have a looser understanding of the mechanics of how Wi-Fi works than they do the physical forces at work for a plane. This means that while the purpose of Wi-Fi is well understood, the technical details exist mostly in the players' imagination, giving them license to contemplate radical alternatives.

Ideating on the Superlatives

As in the previous design sessions, the superlatives became a point of contention for our teen players. Player 2, who is female, specifically asked during the first round of play, "Can we give all of them away, one to each person?", reflecting the same concern for fairness that the younger playtesters showed. Players were directed that the superlatives did not have to be distributed equally, but all of them did have to be awarded. They chose to award one of their superlatives to each player, meaning that each received an equal amount, but not having a clear-cut winner through the person with the most superlatives wasn't their concern. Instead, they focused on how constraining the three chosen superlatives (Most Innovative, Most Useful, and Funniest), as shown in Figure 10:

Player 4: I would add more of those superlative cards, like different ones, because I thought it was somewhat limited what you could describe the inventions as with having only having three to choose from.

Player 1: Yeah, I agree with that.... I know like a lot of [innovations] were funny in a specific way, like one was funny and just ridiculous, putting an umbrella on a drone, but the others were funny in a... I don't know, a different way... it's more like different categories of things....

Author 3: So to improve the game you would get more superlatives that could show the nuance, maybe, or the gradations between funny, or the distinctions between the funniest?"



Figure 10. Players discuss granularity in superlatives.

As sophisticated players, these teens could observe and (almost) articulate the differences between the kinds of amusement they were getting from funny innovations. Had we been free from the constraints of the research study, we believe that these teens would have generated their own superlatives that were just as amusing and creative as the innovations themselves. This observation solidified the decision to allow players to add their own superlatives in the online *Sketchventor* game.

CONCLUSION:

The two play sessions above describe *Sketchventor* both during its design process, and later, with a version of the game approaching its current form. Both reveal several key themes that directly impacted the evolution of the game, which were validated over an iterative process that spans around two years of design and research. Our iterative approach allowed us to validate the new designs that emerged, understanding what worked, and what

did not, alongside the detailed feedback from our diverse group of players (many of whom have asked for card decks to play independently at home).

To conclude, we offer a pedagogical reflection on our research that may be of use in designing other games focused on creative self-efficacy and design thinking skills.

Striking A Balance Between Free Play And Creative Constraints

A major gameplay mechanic inherent in *Sketchventor's* genre of creative ideation games (e.g. *Disruptus* and *The Deck of Lenses*) is that the creativity of players is scaffolded and guided by the constraints of the game system. A way that the tension between free play and creative constraints came to the fore was in the selection, design, and presentation of both our game elements: inventions and verbs. For example, in the first close reading, the ENIAC as a technology constrained players too much, given its very specific and fixed nature. Alternately, certain verbs gave too much freedom. For example, the verb "modify" provided so much freedom of interpretation that there was no useful guide for player action (its close cousin, *adapt*, was eventually incorporated in its stead, overcoming some of the same problems through a carefully considered definition that was printed on the card) . The above tension was again apparent in our second close reading session: Wi-Fi was at first figured by our players as something conceptually fixed by virtue of being so familiar and ubiquitous; however, the scaffolded constraint of the verb card coupled with a mental model of the invention that was clear on its purpose but vague on its workings provided them with an opportunity to rethink something that was generally taken for granted in their day-to-day lives.

As a team of researchers well versed in the history of computation, and who approach design challenges as a matter of

fact in our work, we adapted our game elements to reflect the feedback we received, working towards a set of inventions and verbs that allow for a pleasurable range of freedom, while also providing a scaffold of familiarity and creative guidance.

Beyond Points: Meaningful, Playful Feedback Systems

Based on our early experiences with teen design partners, and then reaffirmed in the multigenerational playtest described above, the game mechanic of superlatives gives players a way to provide feedback to their fellow players in a way that is qualitatively meaningful rather than strictly numerical. That desire for personally meaningful feedback was codified in the ruleset by the design team. Continued playtesting revealed that the ability to customize the superlative served to further augment that meaningfulness, resulting in the introduction of the Wildcard superlative.

Due to our dispositional approach to learning, we strove to introduce learners (and players) to concepts in a way that allows them to gain confidence in their abilities. The early point-based system with an appointed judge was a poor fit for that goal, due to its often exclusionary nature. Through our iterative design process we began to understand that rethinking the feedback system—in part by shifting more agency to players—could help them better recognize, value, and put into practice the many different types of skills that go into gameplay.

Modifiable Rules To Meet Player Needs

With nearly every aspect of *Sketchventor's* final ruleset, we found ourselves incorporating more options for play. In the first close reading, the player gravitation away from a point system is consistent with the social game genre tradition in which we were working (e.g. the fact most players approach *Apples to Apples* without any points whatsoever). Our core ruleset provides a scaffolded suggestion for how to initially play *Sketchventor*, but

also offers options to change those rules to accommodate player tastes, as well as (in the case of the expanded invention deck) skill levels. In our second close reading, it becomes obvious how important this is: although we can anticipate general player actions with our game elements and our rules, in a game focused on creativity, the desire to expand on those core rules is both natural and fruitful.

WELL PLAYED THROUGH PLAYTESTERS AND DESIGN PARTNERS

A common thread runs through the interactions documented in our close readings (indeed, in all our *Sketchventor* play sessions): the interplay between designers and players. As designers we have a number of pre-existing ideas about learning, creativity, and play derived in part from the existing research literature (Gordon, 1961; Roukes, 1988, Eberle, 1972). We created a game based on those ideas and instantiated them in a format reminiscent of other games (e.g., *Apples to Apples* and *Pictionary*), with the goal of disposing players favorably towards engineering and design (Dorph, Cannady & Schunn, 2016; ITSE, 2011). Once we had a working prototype of *Sketchventor*, we opened up the design process to other players, effectively asking them to **engage in a close reading of their own gameplay**. These close readings were then fed back into the game design process, resulting in substantive changes to *Sketchventor*.

There's an old adage in the literature on composition and rhetoric that says good readers make good writers. As we hope our account of a multiyear collaboration with players has demonstrated, there's a corollary to that: good readers—close readers—also make good *designers*.

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