Tandem Transformational Game Design: A Game Design Process Case Study

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Abstract

In transformational game design, developing a clear, shared vision of how the player should change as a result of the game is a critical and ongoing process. However, multidisciplinary teams, particularly those comprised of both expert and novice designers and researchers, may experience barriers to a shared vision due to disparate vocabulary and theoretical frameworks. Adding a new contribution to the growing body of approaches that tackle this challenge, we present Tandem Transformational Game Design—a process that uses physical prototypes to continuously anchor a team's shared alignment to their vision and goals. Drawing on HCI practices that emphasize prototyping to discover and reflect, the Tandem Design approach positions the articulation of game goals and the design of game prototypes as intrinsically intertwined, iterative cycles occurring in tandem with one another, supporting one another as the need arises. We outline the key elements of the Tandem Design approach and illustrate their implementation with our multidisciplinary team's transformational game project, aimed at fostering greater scientific curiosity as an intervention for youth populations currently underrepresented in STEM. It is our hope that other teams working on similarly ill-defined transformational game design problem spaces can adapt our approach in order to solidify their vision and understanding of their own game's goals, iterate on that vision together, and ultimately improve the efficacy and impact of their games.

Keywords: transformational games; game design; playtesting; prototyping; multidisciplinarity

Tandem Transformational Game Design:

A Game Design Process Case Study

Transformational games are designed with the specific intention of changing players' behaviors, attitudes, or knowledge during and after play (Culyba, 2015). One of the biggest predictors of a game's success is the team's level of clarity and alignment on the vision (Tozour, 2015). However, transformational game design teams tend to be comprised of members from a broad range of disciplines, each bringing different perspectives, vocabularies, and areas of expertise to the table. This can make achieving such unification of vision quite challenging. Luckily, there are already several excellent resources, such as Sabrina Culyba's *Transformational Game Field Guide* (2015), available for teams who want to ensure they are considering all of the factors that go into a vision of player transformation. With the present work, our team adds a new approach to existing best practices in transformational game design by integrating a growing body of research from human-computer interaction (HCI) about the benefits of physical prototyping in order to develop a deeper understanding of a game's vision of player transformation, both individually and as a team. We present our approach, Tandem Transformational Game Design (hereafter referred to as Tandem Design), which positions making physical artifacts and articulating goals as intrinsically intertwined cycles occurring in tandem with one another, supporting one another as the need arises. With Tandem Design, the team relies on a deep grounding in relevant literatures to articulate a shared vision of the game's design goals and outcomes and uses common game design processes to both create more fun and effective games and reevaluate the team's understanding of their goals.

This paper presents an overview of Tandem Design and several illustrative game design case studies from our team's ongoing research project, "Sensing Curiosity in Play and Responding" (SCIPR). Our project aims to design and study game-based interventions for fostering curiosity through play, thereby increasing young players' comfort and engagement with science, technology, engineering, and math (STEM) topics. Our team used Tandem Design to develop a better shared understanding of our *problem space* - the conceptualization and operationalization of the construct of curiosity, *intended audienc*e - underrepresented groups in STEM: minority, women, and low socioeconomic status students, and *transformational goals* - increasing curiosity through play. The game case studies we present both elucidate the way that the Tandem Design approach directed our process and provide specific insights for designing games to foster curiosity. To quote designers Joep Frens and Bart Hengeveld (2013, p.1), "to make is to grasp." We present this work in the hope that our Tandem Design approach of making, reflecting, and iterating upon games goals simultaneously will help other teams grasp their visions in a more concrete and ultimately more effective fashion.

Transformational Game Design:
Challenges and Opportunities of Multidisciplinary Teams

Game designers are proficient at creating fun and engaging games, but transformational games require designers to consider other factors, as well. In addition to acute attention to psychological and social factors that affect players willingness and ability to change (Culyba, 2015), effective transformation design also requires deep understanding of relevant content and subject matters. Meeting the "triple bottom line" of a viable, entertaining, and effective transformational game means drawing on theories and methodologies from a range of fields in addition to game design, such as psychology, learning sciences, and HCI (Seidman et al., 2015).

Transformational game design teams often utilize diverse team members, bringing game designers together with experts in the design and research of psychological or educational interventions. It is imperative for these teams to achieve unity while merging their unique methods, tools, and perspectives. For example, psychologists have effectively deployed interventions in non-game contexts, such as in the design of in-school tutoring and mentoring sessions (Good et al., 2003; Stout et al., 2011; Martens et al., 2006). However, fun can never take a back seat; simply inserting an existing intervention into a game or gamifying a proven intervention almost ensures a transformational game's failure. This is in part because games that are overt about their intentions have been shown to be less effective and, moreover, less *fun* (Kaufman & Flanagan, 2015). To this end, transformational game design approaches that aim to more fully integrate or embed known theories or interventions in the design process tend to produce better results and, from players' perspective, better games.

Moreover, research has shown that teams that have a high shared sense of identification with the group tend to exhibit higher levels of learning and productivity, than teams that lack collective identification (Van Der Vegt & Bunderson, 2005). Thus, assembling the diverse team that a successful transformational game requires is not enough; teams must develop unification where none existed previously (Van Der Vegt & Bunderson, 2005). In order to draw strength from a team's multitude of perspectives and domains of expertise and maximize the potential of each teammate, rather than being delayed or inhibited by differences of process and vocabulary, it is important to develop a shared expertise in the game's vision for transformational change.

In order to accomplish this successful intermingling of disciplines, iterative, player-centric game design methods must be combined with psychological insights and iterative design methods (Seidman et al., 2015; Flanagan et al., 2013). To this end, psychologists (or other relevant domain experts) must join forces with game designers, who, domain experts in their own right, often have no established way to bring non-game designer members to the table, and vice versa. Non-designer content experts, meanwhile, may struggle with translating their knowledge of a literature to game design decisions. While transformational game design teams do, in practice, find ways to build on these multiple intellectual traditions, the integration is challenging.

Game design best practices are grounded in rapid prototyping to produce more engaging games (Schell, 2014). These include the rapid iterative testing and evaluation method (Medlock et al., 2002), play-centric design (Fullerton et al., 2006), playtesting with a purpose (Choi et al., 2016) and game jams (Preston et al., 2012). However, in multidisciplinary transformational game design teams, it is likely that some members may have little experience with rapid prototyping or game design, and well-defined processes for onboarding non-designers are still nascent (Culyba, 2015).

Many fields are beginning to incorporate the making of physical artifacts as a method for bringing in non-expert designers into the design conversation, as these artifacts serve as a sort of conversational grounding between groups who think about problems in different ways (Sanders & Stappers, 2013). Some fields have established a long-held tradition of using making as a method for anchoring reflection on both a problem space and proposed interventions. HCI researchers, for example, have developed formalized versions of this approach, including making for validation and exploration and research-through-design (Frens & Hengeveld, 2013; Zimmerman & Forlizzi, 2014). These methods draw on the intellectual tradition of design as a reflective practice, in which artifacts are used to explore abstract constructs and to serve as litmus tests for evaluating theories (Schön, 1983). The intangible object is made, not as an end in and of itself, but as a means for deeper personal and shared understanding of an intangible idea.

Physical prototypes as discussion facilitators are also beginning to appear in game design, although the field's bias toward making certainly isn't new. There is a well-grounded tradition in game design of relying on both design goals and playtesting results to influence iterations of games (Fullerton et al., 2004; Aleven et al., 2010). However, there is less precedent for using multiple physical game prototypes to facilitate a game design team's discussion of the shared mental model of their problem and goals. While many transformational games are often an end unto themselves, deployed in order to change attitudes or behaviors, there is also a burgeoning practice of using transformational games as a means toward understanding, as anchors for discussion and reflection within a team, with the expectation that the vast majority of these "means" will be eventually cut. Tiltfactor uses a process not unlike the Tandem Design approach; Seidman et al. (2015) illustrate how broad iterative prototyping can lead to a crystallization of design goals, abandoning game prototypes that are deemed unable to satisfy any of those goals through further design iteration.

Tandem Transformational Game Design

Tandem Transformational Game Design (Tandem Design) is a process that encourages rapid and divergent iterations of both game prototypes and a team's alignment on its transformational goals. Tandem Design functions in two interrelated cyclical sub-processes we call *game-driven goal delineation* (goal cycle) (Figure 1.A) and *goal-driven game design* (game cycle) (Figure 1.B). A disparate vision can often unseat a team's efforts at creating an effective game, often caused by a very different understanding of goals and lack of shared vocabulary. Tandem Design continuously aligns teammates' mental models of the goals of the game using playtest discoveries and related literature as tools constantly deepening discussion and articulation of both games and delineated goals.

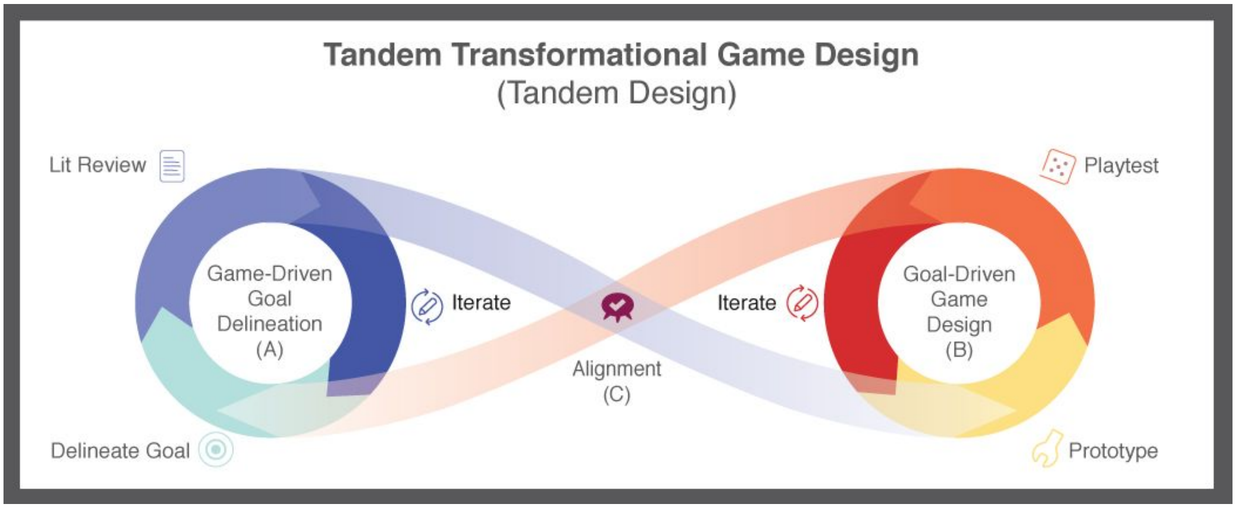


Figure 1. The Tandem Design Process.**Delineate Goal:** Team rearticulating goals for player transformation.**Lit Review:** shared reading of research to develop a shared vocabulary.**Alignment:** The juncture between the two phases. See descriptive paragraph below.**Prototype:** All team members create rapid game prototypes with one or more*delineated goals* as the initial point of inspiration.**Playtest:** Early, often, within team as a goal reflection exercise.**Iterate:** the process of refinement when remaining inside one cycle. *Icons from (Harlow, n.d.; Luck, n.d.)

In summary, Tandem Design (Figure 1) involves teams articulating their goals based on relevant literature (Figure 1.A), then using those goals as starting points for rapid divergent prototyping and playtesting within the team (Figure 1.B), which then in return lead the team to re-articulate their goals with a better shared understanding of them (Figure 1.A).

When a team has completed a full goal cycle or full game cycle they move on to alignment (Figure 1.C) - often employing the use of collectively designed physical and digital artifacts (e.g., lists on a whiteboards, photos of design exercises, game prototypes) that could be remixed and used to illustrate in the moment, but later preserved to capture the team's past iterations of their games or articulated goals. Whether to remain in one cycle after alignment or swing over to the other is a matter of context clarified further in the following two sections. It is critical to not spend too much time in one cycle alone, as game artifacts are needed to ground any discussion of goals, and aligned goals are needed to evaluate the effectiveness of the games.

Game-Driven Goal Delineation

Game-driven goal delineation articulates the team's desired player transformation outcomes through shared game prototype playtesting and reading literature from relevant fields. It is not a substitute for in-person communication about vision, but rather provides a scaffold for *more effective* in-person communication or alignment by grounding all team members in a shared understanding of prior work and foundational theoretical frameworks. This goal cycle (Figure 1.A) ideally provides a highly malleable, working definition, rather than a fixed representation, of the player transformation (e.g., changes to behaviors, emotions, or cognitions) the team's game aims to achieve. Some teams call this *player vision* or *game vision*, but "vision " occasionally is envisioned as something static and intangible, so we use *delineation* to connote a more ongoing, iterative process. Some teams may have a client directive or a single source of expertise that determines starting goals. Others, like our team, may be starting with a disparate collection of research that touches one part or another of a problem space. Regardless, seasoned teams should anticipate that their understanding of their goals will inevitably shift over the course of a project as they develop a deeper understanding of them (Culyba, 2015). Tandem Design uses ideas of reflective practice and the process of alignment to help continuously ensure all team members' deepening understanding of these goals over time.

In order to make the following sections as clear as possible, we will first define the terms we will be using throughout our discussion. For an example of how the terms relate to one another, see Table 1. Our *problem space* is the subject area of player transformation for which we're creating our game. *Elements* are the vague transformational goals drawn from our research about the *problem space* that we use to create the more concrete, actionable behaviors, attitudes, and cognitions that make up our *delineated goals*. Sometimes, the team's evaluation of its defined *elements* spurs additional passes through the cycle to uncover more specific information about an *element* in the literature before more clearly translating it into a delineated goal. These *delineated goals* will then be used to spark ideas about *design decisions* later in the process.

Table 1. From left to right, the table depicts an example progression from abstract problem space to concrete design decisions in the goal cycle.

Problem Space	**Element**	**Empirical Finding (Literature) that More Deeply Explores This Element**	**Delineated Goals: Player will...**	**Design Decision Examples**
How might we make a player feel more curious?	From first-pass lit review: Curious people frame failure as a challenge, not a threat	"Growth Mindset" as a way to make players more open to failure	● Experience failure as an invitation to retry ● Welcome risk-taking ● Avoid words that suggest that they are failing in a unchangeable way	● A game with many opportunities to fail ● A game that requires a certain amount of failure to win ● A game whose setup messages failure in growth mindset terms

To begin developing a common shared vocabulary for discussing a problem space, game-driven goal delineation always involves a preliminary articulation of goals (Figure 2.1), a literature review involving part or all of the team to further develop shared knowledge and vocabulary (Figure 2.2), and a moment of alignment when the team decides whether they have amassed sufficient information and articulated satisfactorily delineated goals to begin prototyping (Figure 2.3). This bias leans toward making when at all possible.

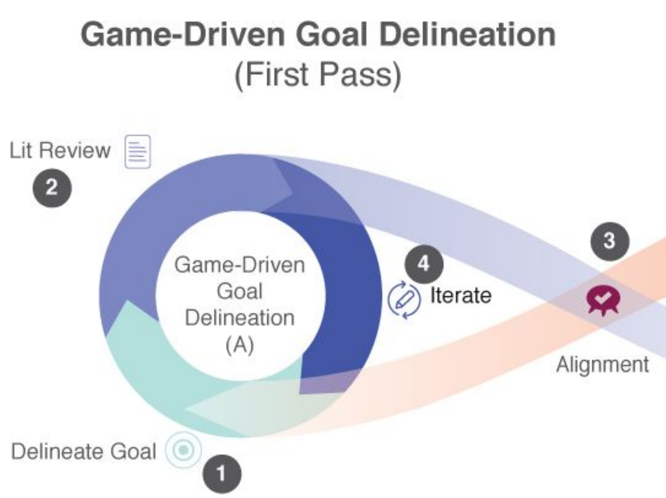


Figure 2. Our team's pathway through our first game-driven goal delineation cycle. Without game prototypes, this first pass is more of a way of getting a sense of all teammates' starting understanding.

Our team began with one broad delineated goal: how might we make players feel more curious during and after gameplay? One teammate then curated an initial literature review, and whittled down a large body of research on curiosity into a number of papers deemed to be most relevant for the entire team to read. We then reviewed the literature and convened to articulate the elements we'd found and to create more specific delineated goals (Figure 2.4).

We articulated these elements—such as *curiosity is deeply intertwined with uncertainty* and *curious people investigate*, along with some delineated goals we thought might come from them, including *comfort asking questions* and *comfort with uncertainty.* At first, our elements were broad and general, but we still preserved these assumptions using concrete artifacts, such as whiteboard lists. We got as specific as possible, with the implicit knowledge that some of our elements could be disproved or abandoned later: assessing the team's current understanding, rather than achieving perfect accuracy, was the goal here.

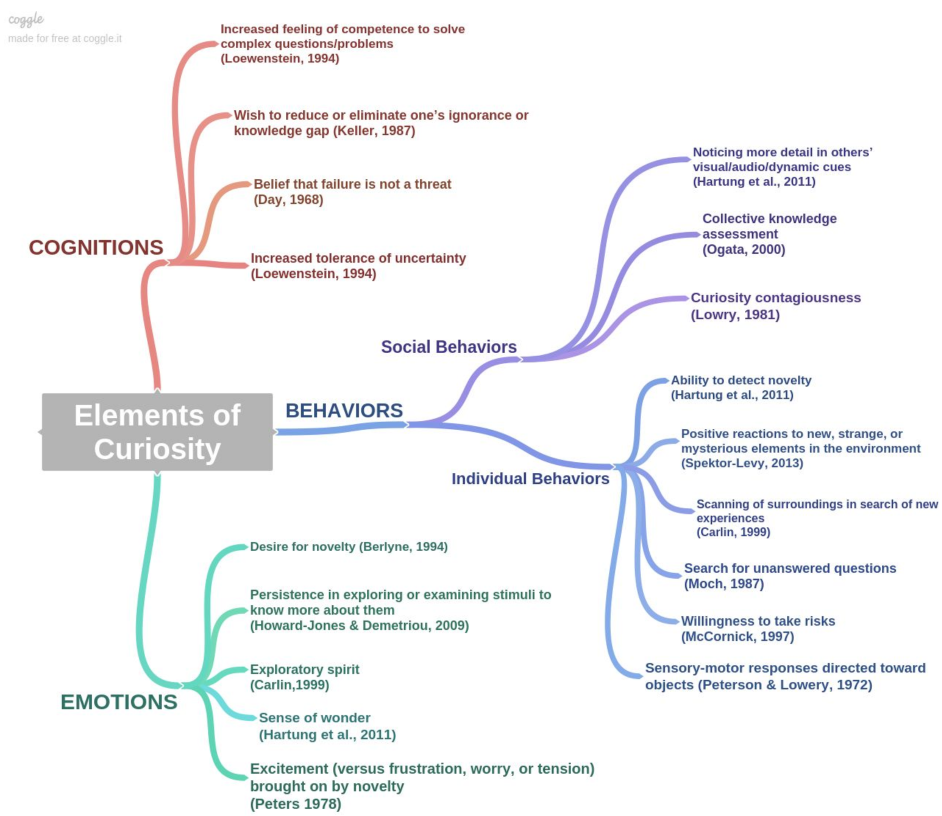


Figure 3. Elements of curiosity that we articulated during our first two passes through the Goal Cycle, which we found helpful to categorize by type of player transformation experienced into behaviors, emotions, and cognitions.

These elements were then used as conversation starters to spark discussion about when in our lives we ourselves had felt curious, which brought to light other delineated goals, such as *feels like failure is not a threat*. Did we feel like our delineated goals addressed everything we'd seen about curiosity in the literature? Were there gaps in our shared understanding that we saw based on our expertise? Were we ready to start prototyping games based on the information we had, even if it wasn't perfect?

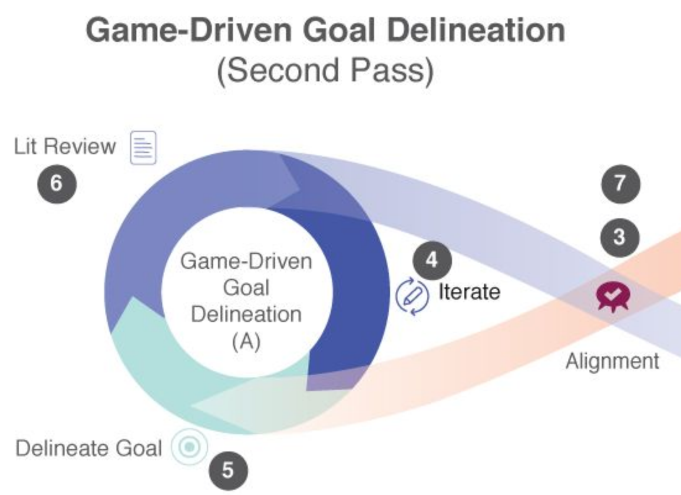
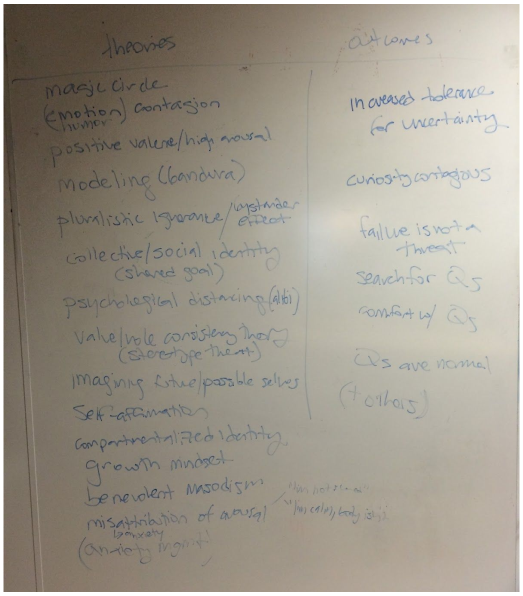


Figure 4. After aligning at (3) in our first goal cycle, our team found a significant gap in our current understanding which would have impacted our ability to prototype our delineated goals, and therefore iterated again (4,5,6) before continuing on to prototyping.

Here after alignment (Figure 4.3) we could either move on to the game cycle or perform another iteration in the goal cycle. After alignment, teams then have a choice: they can remain within the same cycle and iterate or loop over to the opposite cycle. In the goal cycle, when consensus is reached about their delineated goals then it is time to move to the game cycle; when the team is drastically misaligned on goals or finds a gap, the team remains in the goal cycle.



Theories	Outcomes
Magic circle Emotion Contagion Positive Valence/High Arousal Modeling Pluralistic Ignorance Collective/Social Identity Psychological Distancing Value/Role Consistency Imagining future and past selves Self-affirmation Compartmentalization of identity Growth mindset Benevolent Masochism Misattribution of Arousal	Increased tolerance for uncertainty Curiosity contagion Failure not a threat Search for unanswered questions Questions are Normal

Figure 5. Documentation photo (left); transcription (right). A low-fi but highly-used early elements list. After reviewing the curiosity literature, the team extracted the elements (right, then labeled outcomes), brainstormed related moments in their own lives out loud, and extracted related theories from those stories and goals.

We remained in the goal cycle a second time because of a gap in our goals we uncovered when attempting to articulate them as a team. The team's psychology expert identified that we were missing delineated goals about *barriers to bringing about the transformation we wanted* that might keep the game prototypes from working as intended. We delineated our goals one more time (Figure 4.5), reviewed literature about player experience and curiosity barriers (Figure 4.6), and added several important elements, including *avoiding stereotype threat* and *fostering a growth mindset.* The second cycle took less than one week and drastically broadened the space in which we could ideate game concepts and encouraged even more emphasis on player-centered considerations in both our goal delineation and, later, our game design processes. Other teams may experience something similar as they pass through their first game-driven goal delineation cycle: often trying to align a team of experts will uncover gaps in understanding that may be solved more quickly by having the team run through the cycle once more with the goal of finding additional empirical or theoretical papers to deepen or broaden the team's discussion.

After a second round of literature review, goal articulation, and alignment, we had the first draft of our delineated goals (Figure 5). This list of goals also gave us a starting point to begin thinking about game mechanics that might encourage these emotions, behaviors, and cognitions, described more in goal-driven game design. While this list of goals is far beyond what any one game could address alone, we encouraged this breadth of ideas within the team and used rapidly designed game prototypes in the game cycle to test the efficacy of incorporating various goals into context of a transformational game.

Goal-Driven Game Design

In this section, we detail the specific process of goal-driven game design (Figure 1.B) and highlight generalizable pieces of this game cycle that future teams may make use of. Goal-driven game design utilizes existing design practices such as reflective practice, rapid prototyping, and iterative design (Zimmerman et al., 2014; Frens et al., 2013; Nielsen 1993;) while expanding on existing game design practices such as playtests that view the player experience holistically (e.g., what is fun, difficult, confusing, etc.). Goal-driven game design especially emphasizes 1) rapid prototyping for both better gameplay and understanding, and 2) better gathering of information for when teams swing back into the goal cycle. Typical playtesting practice in game design allows a game designer to understand how a player experiences a game. Our game cycle's emphasis on rapid, broad prototyping grounded in one or more delineated goals allows each team member, with little to no prior related experience, to create games in parallel by focusing on one or more delineated goals and developing a deeper understanding of it over time.

Our first cycle of goal-driven game design began after we had passed through the game-driven goal delineation cycle twice. Other teams may only need to do this once before beginning to prototype and only return to the goal cycle later. With a shared body of working knowledge and vocabulary at our disposal from this phase of the process, all teammates individually developed 15 one-sentence game proposals that were flagged with the related delineated goal(s). These ideas, 65 in total, were then shared with the team and grouped in a team clustering exercise during alignment (Figure 6.3) according to theme (e.g., role play, question-games). Then, based on interest, each teammate chose 3 concept clusters to flesh out into 1-page proposals. The team as a whole reviewed all 1-page proposals and voted on what seemed most promising and interesting to them based on both the delineated goals and personal interest. Then, just before the prototyping phase the most expert designers went through and identified what they deemed to be the most promising game concepts and vetoed any ideas that seemed least related to the goals or problematic in any way.

In prototyping phase (Figure 6.1) each designer chose one or more concepts to make either individually or in a pair into a playable game for a total of five prototype plans. The games were messaged as tools for understanding our goals, rather than end games in their own right (concepts would be cut or drastically altered). To ensure the games' alignment with the goals in the prototyping phase, we first used the game's initial description to draft a proposal for which goals related most highly to each game. We translated the goals to specific game mechanics, dynamics, and interaction styles for each game as demonstrated in Table 1.

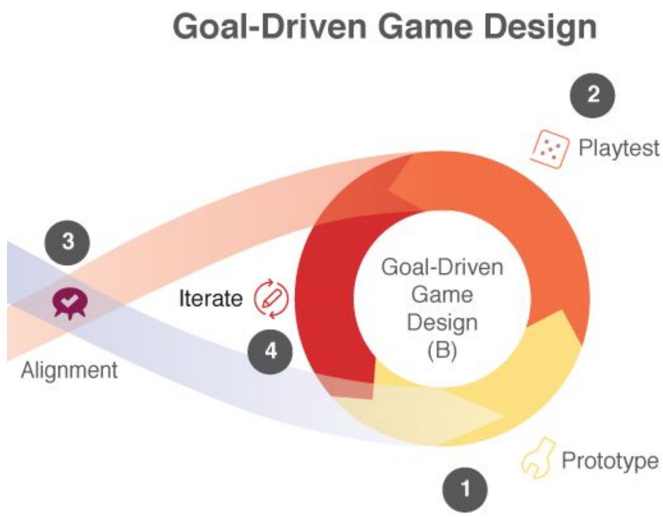


Figure 6. The Goal-Driven Game Design Cycle. Now with delineated goals, team members divergently prototype (1), playtest within the team (2), align with the team on what's working (3), then either move on to game iteration (4) or revisit the goal cycle.

Playtest turnarounds (Figure 6.2) were quick (two weeks or less) and emphasized prototype playability over polish or completeness. While some versions of games were playtested with multiple outside groups (such as participants within our target demographic in the lab as well as participants outside our target population include colleagues and friends), others were iterated after just one playtest within the team itself depending on whether the game was enjoyable and expressed the selected goals. Describing these playtests in-depth is beyond the scope of this paper. In playtesting, we collected varying data including: gameplay behavior in the form of observations, think-aloud protocols, post-play focus group interviews, and self-reported emotional experiences in the form of a emotion "heatmap." These data were analyzed by the team using the following criteria: 1) Did the game appear to encourage the delineated goals you wanted? 2) What other (unexpected) delineated goals did your game design also support? 3) Did your game instantiate goals in a way that aligns with the rest of the team's vision for what success looks like? 4) What other (unexpected) delineated goals did team members notice in your game? 5) Are any of these working against each other? We also asked about and observed for engagement and usability. While this last point is beyond the scope of the paper, it is important to call out as an indispensable component of developing a smoothly functioning game.

Following playtesting, the team re-enters the alignment phase (Figure 6.3). Following prior recommendations from other projects, we designed games for "fun first"; that is, prioritized getting an enjoyable game completed. After alignment, teams may choose to stay in the game cycle or move over to the goal cycle. In the game cycle, when a game is not fun, not balanced well, theme is off, content or design works needs iteration, the team remains in the game cycle (Figure 6.4). When questions, tensions, or clear misunderstandings arise out of playtesting results as to whether a game is meeting the goals, then it is time to revisit the goal cycle.

During the game design process, we used the delineated goals to create as many artifacts as possible to continuously test team alignment to the goals. These artifacts were used alongside game prototypes to discuss and critique one another's' understanding of our vision for player transformation. In iterating and staying within the game cycle (Figure 6.4), we rely on concepts from the EDGE framework (Aleven et al., 2010), re-designing both the game and the transformational learning goal. In order to re-design we utilize the MDA (i.e., mechanics, dynamics, and aesthetics) framework (Aleven et al., 2010) to break down the games and redesign using the focus our playtesting analysis prescribes. This iterative process also sometimes included rapid swapping of game concepts from one teammate to another. Because of the mutually agreed upon goals, there was very little overhead or explanation needed when handing off a prototype and any disparity in approach could be discussed using the delineated goals, rather than personal preference alone. This lack of singular ownership and shared priorities led to more frank, open, and impartial discussions of what appeared to be “working” and what did not.

In goal-driven game design, we continuously utilized parallel ideation to create a large list of viable game ideas, which is shown to generate better ideas (Dow et al., 2012). We repeated this process, diverging to ideate and converging to check each other’s ideas. This process, in which we intentionally spliced games together, diced them apart, and traded ownership, was to avoid a “functional fixedness” of ideas (Adamson, 1952). That is, the inability to see the breadth of possibility space for one concept due to time spent thinking about it deeply. This, too, has been shown to generate better and more innovative ideas (Dow et al., 2012). In goal-driven game design, the game is a tool to explore transformational learning goals; iterations to both delineated goals and game are conducted in the interest of advancing an understanding of those goals.

Goal-driven game designs take the best of many different design processes and uses them in cohesion, creating a method that involves a breadth, depth, and rapidity of concrete artifacts. Our team faced the specific challenge of working as a large, interdisciplinary group of designers. While we had a shared goal, our various disciplines often had completely different vocabulary and approaches to problems; our process grounded us in the reality of physical artifacts and allowed us a starting point for productive shared discourse. Earlier in this paper we described our process for delineating goals.

The following section illustrates this cycle using the four remaining games that have emerged from our use of Tandem Design out of the original sixty-plus concepts. Our games are widely divergent and intentionally so. Our delineated goals cover wide ground in the literature of curiosity and we could not, from the literature alone, determine which interventions would be the most successful. With this in mind, in sync with the HCI practice we are pulling from, we wanted to explore a breadth of ideas. The consistent through line of our delineated goals that make their way into our games is the concept of uncertainty, which is already well situated to be a binding tie between curiosity and games (To et al., 2016).

Case Studies

The SCIPR project's goal is to increase curiosity as a STEM educational intervention for middle school students from marginalized science identity groups (e.g., underrepresented racial minorities and women) during a critical period (Berryman, 1983; AAUW, 2010). Our team used Tandem Transformational Game Design to create four games toward this end. Prior work in this area has shown that games can be effective tools to deliver such interventions for marginalized populations at this age (Hughes, 2007; Kaufman et al., 2015). We chose curiosity as a focus because it directly ties to students' desire and eagerness to learn and to fill gaps in knowledge (Loewenstein, 1994); moreover, games themselves are similarly well-situated both to trigger curiosity and to allow for the observation or measurement of curiosity (To et al., 2016).

We worked in a multi-disciplinary team over the course of nine months. We began developing our goals for the first four months, and in the latter five months began prototyping playable games. Due to the long nature of this project, team members cycled in and out of the project at various phases; the entire team ultimately had two undergraduates, three Masters students, one research assistant, and persisting throughout the entire project were one PhD student and two university faculty. The backgrounds of all team members included HCI

Research, HCI Practice, Psychology, Game Design, Learning Sciences, and Education. Such diversity provided the challenges mentioned earlier, but ultimately helped us gain multiple perspectives in the game design process and create more integrative products.

At this stage of our research we have narrowed down to four playable games that aimed to encourage curiosity and target specific curiosity elements, as defined by our delineated goals: *Alter Egos*, *Outbreak*, *Combinations*, and *First to Launch*. In this section we present a deep dive on the game *Outbreak* with additional brief descriptions of the other three games as case studies for Tandem Design.

Outbreak: A Deep Dive on Tandem Transformational Game Design

Outbreak is a collaborative question-asking game for two to five players. The game positions players as remote radio dispatchers who must carefully pose questions to a robot while it explores an unknown laboratory in search of a cure for a deadly virus. Players collectively decide how to pick a team of game characters equipped with tools to address each room's unique threats, including: zombies, monsters, angry people, hidden objects, or ghosts, which call for different characters' skills.

Outbreak, like all of our games, began as a brief mash-up of prompts contributed and then discussed by all teammates. From the original 65 concepts, ideas such as a game with a "tome" and a "choose your own adventure" or "escape" style game were flagged by team experts as having potential to promote our delineated goals. In particular, we anticipated that specific types of curiosity, including narrative curiosity and curiosity about exploring a space (To et al., 2016), would be particularly likely to emerge from these genres of game. These dovetailed well, we hypothesized, with how a game about exploration might set up one of our delineated goals (comfort with uncertainty), particularly in a science-themed narrative space. Later, as the game iterations presented opportunities, we added other possible goals, such as comfort asking questions and the use of psychological distancing (Table 3). Allowing for many different goal considerations within a single game was an intentional part of our iterative design process: we often worked in a style in which we allowed games to get “big and messy” before exploring what was or wasn’t working toward our goals and what elements to cut or revise.

At the end of an alignment stage (Figure 6.3) the team handed a 1-paragraph concept description of a storytelling escape game to a single teammate to move onto to prototype a playable game (Figure 6.1). During an internal team playtest (Figure 6.2), we discovered something important: only about two minutes of gameplay had been completed, because one of the largest challenges of creating a storytelling game was developing written content alongside mechanics. The mechanics were going to influence the story, and vice versa. And so, in the second iteration (Figure 6.4), we agreed as a team on a pathway forward that minimized the immediate need to generate content before testing mechanics, with the promise of later drawing on everyone’s contributions to generate written content.

As the game design process progressed, the team would utilize the alignment stages (Figure 6.3) to co-design or hold content-creation sessions in order to overcome such roadblocks. These sessions consisted largely of a prompt followed by a 5-minute individual “writing session,” coming back together to share ideas, and a final 5-minute session in which to build on individual ideas after hearing others’. The teammate leading the prototype also spent a portion of time brainstorming related, already-existing games with the team and then playing them while taking notes about what was working.

Like our other games, a commitment to playtesting early and often was at the fore, with a team playthrough and critique every two weeks (Figure 6.2). Like our other storytelling game, and because we wanted to allow our games to get “big and messy” before paring down, early versions of *Outbreak* contained many mechanics and ideas that ultimately were cut. Prototypes often alternately became either about “going wide” with ideas, materials, designs, and mechanisms grounded in one or more goals or “going narrow” and cutting or compressing features using the MDA framework. Playtests were visited with a position of open-mindedness and rigorous honesty about what was working most and least well, with every teammate contributing their personal opinions about this, grounded in their understanding of the shared vision of what we were trying to achieve. Each game cycle provided us vital information to our goal cycle, including the fact that some of our delineated goals, such as *feels curious about a narrative* and *comfort with uncertainty,* might be at odds.

More Games

Combinations is a team-based asymmetric card matching game. In the game, one player acts as the “mastermind” who secretly assigns scores to the different ingredients. For example, in the ice cream cone themed version, a cherry might be worth 10 points, chocolate syrup 100, and vanilla ice cream 1000. Other unmarked ingredients might be a wafer, strawberry ice cream, and raspberry syrup. On a turn, other players choose cards made up of the various ingredients and receive score tokens based on the composite total of the ingredients’ scores. They must use this information to figure out the hidden ingredient scores at the end of the game to first beat the mastermind and whichever team has the highest total score wins the game. *Combinations* forces players to deal with initial uncertainty, but encourages them to rely on team members to seek answers and assess knowledge collectively (Table 3).

Table 3. A subset of the top five most common elements and top five most common related theories from our delineated goals as they are integrated within our current games. (Forconi, n.d.)

	Alter Egos	Outbreak	Combinations	First to Launch
Failure is not a threat	✓	✓		
Increased Tolerance for Uncertainty			✓	✓
Collective Knowledge Assessment		✓	✓	✓
Norms about Questions		✓		✓
Search for Unanswered Q's		✓	✓	✓
Misattribution of Arousal		✓	✓	
Collective Identity/ Shared Goal	✓	✓		✓
Growth Mindset	✓			
Psychological Distancing	✓	✓		
Imagining Future/ Possible Selves	✓			✓

First to Launch is a competitive hidden information and card-swapping game. Two teams race to solve a problem with their spaceship by gathering the correct tools for the job in order to launch first. Teams receive a puzzle with hints for tools they need, tiles with different tools and descriptions for what the tools can do (e.g., “oil can - this can grease rusty things”) and must gather the right tools for the job by stealing from the other team, trading with hidden or exposed tiles on the board, and then calling the end of the game when they are ready to guess if they beat the challenge. *First to Launch* has goals similar to those of *Combinations* but additionally encourages question-asking to find information (Table 3) and utilizes a more explicitly STEM-related theme.

Alter Egos is a competitive, identity-building, storytelling card game for up to five players. To win, players must build a character with the most numerous and diverse set of personal identities, ranging from values-based (“good friend,” “family oriented,” “independent") to interests-based (“music lover,” “comedian,” “inventor”). *Alter Egos* has changed significantly from the original concept (a collaborative identity-building roleplaying game) and now focuses on encouraging a growth mindset (Table 3).

Challenges

Throughout the process, our team encountered numerous challenges. One of the primary concerns we encountered was how to know which games were the “right ones” to keep or cut during our alignment evaluations. Relatedly, how would we know what was working for us would ultimately work for our target demographic? And finally, how would we know if the game outcomes were truly making players feel and express more curiosity?

Likewise, we could not be sure in the initial phases that what worked as a game for us would transfer directly to our audience of middle school students. However, early and rapid playtesting, even without the target demographic, is infinitely better than no playtesting at all (Schell, 2014). Because project constraints meant it would be months before we got a game in front of our target demographic, we needed to be realistic about what was good for the games.

Though we did encounter some changes that needed to be made when introducing the games to middle school students, they were far fewer than if we had attempted to design a game for middle schoolers that was "fun for them" but never tested to see if it was fun for us.

The uncertainty around whether a particular game would successfully allow players to feel and express more curiosity mirrors concerns that many transformational game design teams face, especially when working in an ill-defined space. We're developing measures alongside the game prototypes, so how do we know which measures to move forward with in the early development phases? This is, again, why testing four low-fidelity prototypes internally and testing multiple concepts with the target demographic before narrowing to one concept was such a central part of our process. This is also why we addressed different goals with different games; we wanted to explore broadly to find points of impact. It can be tempting to, early on, decide which measures will produce the "right" answer before more information can be discovered through making the actual game cycle.

Limitations & Future Work

A key limitation of this work is that the transformative goals of the games we have designed have not yet been formally evaluated. That is, to corroborate the informal evidence we have been gathering of our games' impact during playtesting (e.g., through observational and brief self-report measures), it is imperative to conduct more systematic, controlled investigations once the games' designs have undergone further iterations. Another key component not represented in the Tandem Design model, but nonetheless vital for most transformational design teams, is the ultimate deployment or dissemination of their games among target populations and real-life settings. In our case, we will ultimately seek to deploy our games in local schools and afterschool programs to test both whether the games might feasibly exist in those target locations (paying special attention to fun, run time, and degree of fit with pre-existing ecosystem, among other things) and whether they suit the needs and preferences of the target demographic. The knowledge and insights gained from both formal assessment and deployment activities could (and often should) bring teams back to either cycle of the Tandem Design model, in order to re-assess the game's alignment with its goals and the potential need for further design iterations.

Conclusion

Although transformational games often have a multidisciplinary team of experts working in spaces that are not well-traversed or well-defined, there is no less of a need to have a shared vocabulary and vision than a standard team of designers or researchers. We describe the SCIPR project's games for curiosity as a working example of developing a shared vision and process that enhances the output of rather than suffering from the variety of disciplines many transformational game teams contain. We present a model of how to define and talk about player transformation goals by starting with a unanimously agreed-upon but expert-curated set of literature that draws from all disciplines that relate to the game's problem space. Our goals were (and continue to be) fed through theories and prior empirical work from HCI, game design, and developmental/social psychology, as well as game prototypes. Together, these disciplines provided a diverse but complementary set of lenses through which we devised a goals centering on a mutually agreed-upon set of "curiosity outcomes," behaviors, emotions, and cognitions that pertain to curiosity, as well as their potential catalysts and inhibitors, prioritized in order of the team's estimation of their relative promise or likelihood for a particular game design.

From there, we describe how a team might use such goals to get the entire team immersed in related literature and games, creating a wide variety of game prototypes, and productively critiquing each other's work with little overhead. These working critiques of game prototypes will, in turn, influence the original goals, changing how the team thinks and talks about player transformation and how to better make it happen. We prioritize creating a vast breadth of prototypes and narrowing based on a dual bottom line of fun and impact while designing for fun first, and a flexibility of approach that might include mash-ups and dissections of any number of concepts, as well as trading off on design “leads” for any given game. It is our hope that this flexible process will help teams facing similar problems come together and better utilize each and every team member’s expertise while allowing them to contribute directly to the game design and prototyping process.

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References

Adamson, R. E. (1952). Functional fixedness as related to problem solving: a repetition of three experiments. *Journal of experimental psychology*, *44*(4), 288.

Aleven, V., Myers, E., Easterday, M., & Ogan, A. (2010, April). Toward a framework for the analysis and design of educational games. In *Digital Game and Intelligent Toy Enhanced Learning (DIGITEL), 2010 Third IEEE International Conference on* (pp. 69-76). IEEE.

Berryman, S. E. (1983). Who Will Do Science? Trends, and Their Causes in Minority and Female Representation among Holders of Advanced Degrees in Science and Mathematics. A Special Report.

Carlin, K. A. (1999). *The impact of curiosity on learning during a school field trip to the zoo*. UMI Company.

Choi, J.O., Forlizzi, J., Christel, M., Bates, M., and Hammer, J. Playtesting: Understanding the player experience from data to design. *upcoming publication*, (2016)

Culyba, S. (2015). Transformational Games: A Field Guide for Design Leaders. Unpublished manuscript

Day, H. I. (1968). Some determinants of looking time under different instructional sets. *Perception & Psychophysics*, 4(5), 279-281.

Dow, S. P., Glassco, A., Kass, J., Schwarz, M., Schwartz, D. L., & Klemmer, S. R. (2012). Parallel prototyping leads to better design results, more divergence, and increased self-efficacy. In *Design Thinking Research* (pp. 127-153). Springer Berlin Heidelberg.

Flanagan, M., Punjasthikul, S., Seidman, M., Kaufman, G. (2013). Citizen Archivists at Play: Game Design for Gathering Metadata for Cultural Heritage Institutions. *Proceedings of DiGRA 2013, Atlanta, Georgia, August 2013.*

Forconi, S. *Noun projec*t.

Frens, J.W. & Hengeveld, B.J. (2013). To make is to grasp. 5th International Congress of International Association of Societies of Design Research (IASDR), 26-30 August 2013, Tokyo Tokyo, Japan: Technische Universiteit Eindhoven.

Fullerton, T., Chen, J., Santiago, K., Nelson, E., Diamante, V., Meyers, A., ... & DeWeese, J. (2006, July). That cloud game: dreaming (and doing) innovative game design. In *Proceedings of the 2006 ACM SIGGRAPH symposium on Videogames* (pp. 51-59). ACM.

Fullerton, T., Swain, C., & Hoffman, S. (2004). *Game design workshop: Designing, prototyping, & playtesting games*. CRC Press.

Good, C., Aronson, J., & Inzlicht, M. (2003). Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat. *Journal of Applied Developmental Psychology*, *24*(6), 645-662.

Harlow, B. *Noun project.*

Hartung, F. M., & Renner, B. (2011). Social curiosity and interpersonal perception: a judge× trait interaction. *Personality and Social Psychology Bulletin*, 0146167211400618.

Hill, C., Corbett, C., & St Rose, A. (2010). *Why so few? Women in Science, Technology, Engineering, and Mathematics*. American Association of University Women. 1111 Sixteenth Street NW, Washington, DC 20036.

Howard-Jones, P. A., & Demetriou, S. (2009). Uncertainty and engagement with learning games. *Instructional Science*, 37(6), 519-536.

Hughes, K. (2007). Design to promote girls' agency through educational games: The Click! Urban adventure. *YB Kafai, C. Heeter, J. Denner, & J. Sun (Eds.)*.

Luck, Y. *Noun project*.

Kaufman, G., & Flanagan, M. (2015). A psychologically "embedded" approach to designing games for prosocial causes. *Cyberpsychology: The Journal for Psychosocial Research on Cyberspace, article 5. doi: 10.5817/CP2015-3-5.*

Kaufman, G., Flanagan, M., & Seidman, M. (2015). Creating stealth game interventions for attitude and behavior change: An “Embedded Design” model. In *Proceedings of the Digital Games Research Association (DiGRA) Conference*.

Keller, H., & Schölmerich, A. (1987). Infant vocalizations and parental reactions during the first 4 months of life. *Developmental Psychology*, 23(1), 62.

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological bulletin*, *116*(1), 75.

Lowry, N. & Johnson, D.W. (1981). Effects of controversy on epistemic curiosity, achievement, and attitudes. *The Journal of Social Psychology.* 115. 31-43.

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological bulletin*, 116(1), 75.

Martens, A., Johns, M., Greenberg, J., & Schimel, J. (2006). Combating stereotype threat: The effect of self-affirmation on women’s intellectual performance. *Journal of Experimental Social Psychology*, *42*(2), 236-243.

Medlock, M. C., Wixon, D., Terrano, M., Romero, R., & Fulton, B. (2002). Using the RITE method to improve products: A definition and a case study. *Usability Professionals Association*, *51*.

Moch, M. (1987). Asking questions: An expression of epistemological curiosity in children. *Curiosity, imagination and play: On the development of spontaneous cognitive and motivational processes*, 198-211.

Nielsen, J. (1993). Iterative user-interface design. Computer, 26(11), 32-41.

Ogata, H., & Yano, Y. (2000). Combining knowledge awareness and information filtering in an open-ended collaborative learning environment. *International Journal of Artificial Intelligence in Education (IJAIED)*, 11, 33-46.

Peterson, R.W. & Lowery, L.F. (1972). The use of motor activity as an index of curiosity in children. *Journal of Research in Science Teaching.*

Preston, J. A., Chastine, J., O'Donnell, C., Tseng, T., & MacIntyre, B. (2012). Game jams: Community, motivations, and learning among jammers. *International Journal of Game-Based Learning (IJGBL)*, *2*(3), 51-70.

Sanders, E. B. N., & Stappers, P. J. (2013). Convivial Toolbox: generative design research for the fuzzy front end.

Schell, J. (2014). *The Art of Game Design: A book of lenses*. CRC Press.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action* (Vol. 5126). Basic books.

Seidman, M., Flanagan, M., & Kaufman, G. (2015). Failed games: Lessons learned from promising but problematic game prototypes in designing for diversity. In *Proceedings of the Digital Games Research Association (DiGRA) Conference*.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of personality and social psychology*, *100*(2), 255.

To, A., Ali, S., Kaufman, G., Hammer, J. (2016) Integrating Curiosity and Uncertainty in Game Design. *In Proceedings of DiGRA/FDG Joint International Conference*.

Tozour, P. (2015, January 13). The game outcomes project, part 3: Game development factors. Retrieved from http://www.gamasutra.com/blogs/PaulTozour/20150113/233922/The_Game_Outcomes_Project_Part_3_Game_Development_Factors.php#DesignRiskManagement

Van Der Vegt, G., & Bunderson, J. (2005). Learning and Performance in Multidisciplinary Teams: The Importance of Collective Team Identification. *The Academy of Management Journal*, 48(3), 532-547.

Zimmerman, J., & Forlizzi, J. (2014). Research through design in HCI. In *Ways of Knowing in HCI* (pp. 167-189). Springer New York.