An Experiment in Teaching with Design Thinking

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Abstract

This paper presents an experiment in teaching undergraduates with design thinking, a problem-solving methodology. Students participated in a design thinking project—designing games related to course subject—in two different undergraduate courses over a four-year period. The project was modified over time based on observations of students' behavior and their academic performance with the goal of improving students' experience of design thinking. These modifications included the introduction of a formal method of creative ideation, evaluating the designs of existing games, and peer feedback on the games designed by students. Some evidence emerged that these changes improved students' reactions to design thinking but did not impair their ability to acquire course-specific domain knowledge.

Design Thinking

Design thinking is an iterative process of rigorously testing innovative solutions to a relevant problem (Dym et al. 2005, 104-105; Fouché and Crowley 2017, 66; Gaydos 2015, 478). It has been used successfully as a pedagogical method in a variety of primary, secondary, and post-secondary curricula (Aflatoony 2018; Chon and Sim 2019; Cook and Bush 2018; Dym et al. 2005; Schiele and Chen 2018; Trowbridge 2018; Gallagher 2019).

Design thinking can be separated into three phases: problem definition, creative ideation, and experimentation. Problem definition rests on the presupposition that developing effective solutions "requires a deep, empathetic understanding of user needs" (Trowbridge et al. 2018, 1200). By making the needs of others central to the problem-solving process, design thinking pushes practitioners to engage with multiple perspectives and become aware of latent assumptions.

Once the nature of the problem is understood, designers need to ideate potential solutions. Instructors often expect informal classroom brainstorming activities to fulfill this function; however, undergraduates typically lack the necessary confidence and expertise to engage in problem solving in this type of impromptu setting. The use of formal methods for creative ideation can obviate this problem.

One such method is SCAMPER, an acronym for substitute, combine, adapt, modify, put to other use, eliminate, and reverse. These seven techniques, when used together, stimulate non-linear, innovative thinking about how a problem's existing solution can be altered and improved (Elmansy 2015). The questions that comprise SCAMPER are:

- Substitute: what part of the solution be substituted for some other part?
- Combine: can two separate aspects of the solution be integrated into one?
- Adapt: can something used in a dissimilar field be adapted for use in the current context?
- Modify: can part of the existing solution be modified, enhanced, or simplified?
- Put to other use: can one component of the solution serve some other function?
- Eliminate: can any part of the solution can be removed or omitted?
- Reverse: what happens if a process that comprises part of the solution is reversed?

SCAMPER has been used in as a tool in fields such as psychological counseling (Gladding 2011), corporate product innovation (Michalko 2006), and elementary education (Myrmel 2003). Radziszewski (2017) concluded that SCAMPER helped college undergraduates become more adept at creative problem-solving and more willing to experiment.

In the final step of design thinking, the solutions developed in the ideation phase are experimentally tested, often through prototyping. It is during this last stage that ideas take material form, are evaluated against the desired outcome, and reflected upon (Chon and Sim 2019, 193).

Design thinking's iterative process of problem definition, ideation, and testing enables practitioners to monitor their progress in understanding the unfamiliar, making it easy for students to recognize when and what they have learned. This awareness in turn leads to feelings of autonomy, accomplishment, and pleasure on the part of the student (Enterline and Jepsen 2009; Koh et al. 2010; Mitchell and Savill-Smith 2004).

Games

Games are a product of design thinking. Each element in a game's design represents a deliberate attempt by the designer to benefit the game's end users. Game designers must determine the problem that a game is supposed to address, the resources that are needed to play the game, and the possible actions of the game's players (Jones 1998, 343).

There is evidence that games can help foster the development of students' analytical thinking skills (Crocco et al. 2016), intellectual engagement and discipline-oriented thinking (Asal et al. 2014), intrinsic motivation to learn (Sørebø and Hæhre 2012), empathy toward others (Bachen et al. 2012), and willingness to interact with peers (Nadolny et al 2017). However, these studies focus on the educational effects of game *play* rather than the effects of game *design*. The pedagogical literature is relatively silent on the use of game design as a teaching tool. Jones (1998, 342) argues that a classroom exercise in which students design a simple simulation encourages teachers "to share power and responsibility" with students, but he does not discuss its ability to facilitate students' achievement of particular learning outcomes.

Teaching with Design Thinking

Having used classroom game play as part of my teaching repertoire for several years, I decided to experiment with students designing their own games, in the hopes that the experience would help them learn course content. I began with a first-year seminar, a general education requirement for new students, in Fall 2016. I presented the class with a pre-defined problem: the need for games on refugee migration, aid, and resettlement, respectively, that could educate members of the public about each of these topics. Before beginning each of round of game design, students individually completed a preparatory writing assignment to familiarize themselves with the games' real-world contexts. Teams were informed that they could create any type of game as long as the it addressed the defined problem. I reserved class time students to participate in game design and construction, but I did not provide any instruction in creative ideation. Once completed, games were played by other teams and scored using a rubric on different principles of game design. Students also ranked their and their teammates contributions to each game project through an electronic survey administered through Google Forms. The preparatory writing assignments, rubric scores, and team evaluations were collectively worth one-third of students' final course grades. Students also participated in a grant-funded community engagement project with a local non-profit organization that assisted resettled refugees (Raymond 2017). An essay that reflected on this experience composed an additional seven percent of the course grade.

As shown in the right-most column in Table 1, the class performed well academically. Course evaluation scores, shown in Table 2, were similar to those from my other courses. Students made positive comments about their experiences in the course in the evaluations and in the reflective essay.

Year	Students	Average
2016	21	88
2017	41	77
2018	17	82
2019	22	79

Table 1: Class Averages

	2016	2017	2018	2019
N	13	28	6	15
Syllabus clear	4.6	3.0	4.0	4.1
Content challenging	4.1	3.4	3.8	3.9
Learned a great deal	4.2	2.2	3.8	3.7
Became more independent thinker	4.3	2.3	4	4.1
Teaching helped me learn material	4.0	2.0	3.7	4.2
Free to express views	3.9	2.5	4.3	4.3

Table 2: Evaluation Scores

In 2017, I taught two sections of the first-year seminar with content similar to that of previous year. Game design was organized in the same manner. The only major change in the course was the absence of community engagement. The game design project again accounted for approximately one-third of the final course grade.

Students in the course performed much worse academically than they had in 2016 and evaluation results declined dramatically, as indicated in Tables 1 and 2. The games designed by students bore little relation to the defined problem and exhibited a low degree of creative ideation. Overall, students appeared to be far less engaged than students who were in the course the year before. Other instructors of first-year seminar sections reported similar experiences.

In Fall 2018, I used game design yet again, but this time in an upper-level course on economic development and environmental politics. This time, my approach was more structured. First, I introduced students to SCAMPER in brief lectures at the beginning of semester and gave students the opportunity to practice SCAMPER on ordinary objects in class. Second, students applied SCAMPER to *California Water Crisis*, an educational game about water politics, in a writing assignment.[1] After the assignment was submitted, students met with their teammates to develop a single set of recommendations for improving *California Water Crisis*. Each team delivered an ungraded presentation of its recommendations to the class.

After practicing with *California Water Crisis*, students wrote a proposal in which they applied SCAMPER to a game of their choice, to create a new game on an economic or environmental topic. As with *California Water Crisis*, teammates discussed their proposals with each other in class, agreed upon a topic and design for the new game, and presented their plan to rest of the class.

Teams then built their games, which were played by other teams at the end of the semester. In an assignment, students wrote about how well the games reflected principles of game design and the use of SCAMPER. Teams did not award scores to each other's games, as had happened in 2016 and 2017, but the entire design project again comprised about one-third of the course grade.

On average, the 2018 class performed better academically than the 2017 class, though not as well as the class in 2016, as shown in Table 1. Course evaluation scores had a similar pattern. Students in 2018 were more enthusiastic about design-related activities than those from the year before. However, they frequently scored poorly on quizzes, as shown in Table 3. These quizzes were worth eighteen percent of the final course grade.

	N	Ave % Score
2018	17	37
2019	22	63

Table 3: Average Quiz Scores

I employed game design in the same course in Fall 2019 but made additional changes to the project's organization. Students in 2018 stated that some of the mechanics in

[1] Available at https://www.californiarailmap.com/cawater.

California Water Crisis lessened their enjoyment of the game, so I replaced it with *Stop Disasters* and *Wingspan*. *Stop Disasters* is an online game in which a single player tries to mitigate the effects of a natural disaster on a community. *Wingspan* is a board game where players compete against each other to build the most robust bird habitat. The Fall 2019 course began with students playing both games and evaluating in separate writing assignments. In a third assignment, students applied SCAMPER to either *Stop Disasters* or *Wingspan* to design a new game about an economic or environmental problem in the local community.

Next, teammates conferred with each other in class to decide whether *Stop Disasters* or *Wingspan* would serve as the foundation for the design of the game created by the team. Teams then constructed their games. Students played the games that had been created by other teams and generated written evaluations. In a change from the previous year, I provided each team with the evaluations of its game that classmates had written after removing students' names. Teams were instructed to use this information as feedback to improve the design of their games. Once teams had altered the designs of their games, the games were played a second time, but by a different team. Students then completed second game evaluation.

The games produced in 2019 were more complex, more reflective of course content, and given student reactions, more enjoyable to play than the games students had created in the previous three years. Students appeared to benefit from evaluating the designs of two existing games before applying SCAMPER. Requiring that teams choose one of these two games as the basis for the design of a new game also seemed productive.

The class performed slightly worse academically than the 2018 class, yet quiz scores were higher, a phenomenon that I attribute to two factors: first, the 2019 class included several students who performed at a C or D level because they failed to complete several writing assignments, and second, I had changed quiz questions from a short-answer to a multiple choice format. As shown in Table 2, average course evaluation scores were the same or higher than in 2018, except for one question, which was only a tenth of a point lower.

For 2019 I also instituted an ungraded pre/post test on several of the economic concepts that formed the basis of the course, which I administered in the first and last weeks of the semester. Posttest scores were dramatically higher than on the pretest, shown in Table 4, suggesting an increase in students' domain knowledge.

	% Correct		
Test Questions	Pre N= 21	Post N = 16	% Change
Poverty Trap	52	100	92
Diminishing Returns to Capital	52	75	44
Skill Matching	5	88	1,660
Common Pool Resource Problem	48	81	69
Moral Hazard	38	100	163

Table 4: Pre/Post Test Percentage Correct Answers

Conclusions

It is difficult to quantify whether my use of pedagogy rooted in design thinking helped students learn. The population of students that participated in game design projects changed from those in their first semester college enrolled in a required general education course to sophomores, juniors, and seniors in a course that was part of their majors. The ways in which the projects were scaffolded varied from year to year. Small sample sizes preclude performing a statistical analysis. Organizing data in the form of a truth table—Table 5—suggests that:

- The community engagement project had a far greater and more positive influence than game design on student academic performance and course evaluation results in the sections of first-year seminar that I taught in 2016 and 2017.
- Adding structure to students' experience of the design thinking process—for example, through a formal creative ideation technique like SCAMPER and practice in evaluating existing designs—increases student satisfaction, at least in upper-level courses related to students' majors.
- Inclusion of a design project that accounts for a substantial amount of the final course grade did not seem to impair students' learning of course content.

Case	Course Type	Community Engagement Project	Formal Creative Ideation Method	Limited Game Choice	Game Evaluation Prior to Design	Iterative Peer Feedback	Class Ave > C+	Eval Scores ≥ 3.7
1	Gen Ed	Yes	No	No	No	No	Yes	Yes
2	Gen Ed	No	No	No	No	No	No	No
3	Major	No	Yes	Yes	No	No	Yes	Yes
4	Major	No	Yes	Yes	Yes	Yes	No	Yes

Table 5: Design Thinking Project Over Time

The design project may have improved students' problem-solving skills, ability to collaborate, and intrinsic motivation to learn; however, these were not intended outcomes and were not formally measured.

The results from the 2017 first-year seminar suggests that students who expect college to reflect a banking model of education, where information transmitted by an authority figure is passively received (Freire 1970), may react negatively to exercises in design thinking. Design requires active collaboration with others while under minimal supervision from above. For some students, interaction with peers can reinforce pre-existing risk aversion (Ahern, Duchin, and Shumway 2014, 3214), and any teaching method is less effective when students are not motivated to exercise leadership over their own learning (Asal et al. 2014, 348). If design thinking is to succeed as a pedagogical strategy, students must value learning more than simplistic actions taken solely to ensure the achievement of a desired grade (Machemer and Crawford 2007, 26).

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