Facilitating Undergraduate Experimental Game Design: A Pilot Study with *Celestial Harmony*

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Abstract. Encouraging undergraduate students and other novices to engage with game design experimentation requires the creation of a space where they can research without fear of failure. Creating a safe space requires addressing the class format for both production and grades. We conducted a pilot study with a group in a capstone game design course, seeking to create this safe space for experimentation by framing our roles not as expert instructors but partners in learning, where we offered guidance and mentorship to the groups while retaining student autonomy in much of the game design decisions. In this paper, we identify three key strategies for making students feel more comfortable in an experimental space that is also integrated into a required course. These three strategies are: modifying the grading schema, encouraging rapid prototyping, and providing frequent feedback. Though this guide is focused on experimental game design, many of the lessons we describe could be applied to courses in other fields where experimentation or loosely-defined works are the objective.

Keywords: Experimental Game Design, Project-Based Learning, Partners in Learning

1 Introduction

Experimentation is an important part of higher-level thinking skills, particularly when engaging in the process of evaluation [1]. To successfully engage in experimentation, students need to push beyond the known and engage with concepts and material that they have not yet explored [2] and be able to evaluate the outcomes based on their objectives. Teaching through hands-on projects encouraging learner exploration and experimentation, however, can be difficult.

Educator philosophies have been experiencing a shift from direct instruction models—often referred to as the professor as the "sage on the stage"—to more student-centered models turning the instructor role to that of a mentor or "guide on the side" [3]. This student-centered approach puts the responsibility for learning in the hands of the students themselves, and is thought to increase student engagement, autonomy, and self-directed learning abilities [4]. Though this is more commonly seen in K-12 instruction, where the ages of students as well as class sizes are generally lower than in secondary education, there is a push in higher education to deviate from the lecture-based

mode of instruction and experiment with more innovative ways to encourage student learning and engagement with the material [5][6].

Additionally, many universities have begun encouraging faculty to increase the frequency and authenticity of student experiential learning in coursework [7]. It is believed that giving students opportunities to gain experience in environments that simulate those in which the students participate in after graduating—in their major field of focus or not—will enhance their overall learning experience. Students who have opportunities to gain real experience that can be listed on a résumé while also practicing and improving the "soft-skills" that professional work environments require (emotional intelligence, leadership skills, effective team communication, etc.) are in better positions to obtain and retain meaningful employment [8].

Furthermore, those employed in rapidly-growing fields like interactive media and games must have the ability to adapt and experiment with technology that is constantly changing. Thriving in a field such as this requires the professional to be comfortable in an environment full of constant shifts and uncertainty while keeping up with the shifting expertise required to stay relevant in the industry [9]. If undergraduates can be exposed to this facet of the industry prior to graduation, they will be at an advantage upon entering the professional realm [10].

In the capstone Game Design Workshop class at our university, students work together in groups of six to twenty to create a fully functional video game in one semester. Traditionally in this class, the students start with documentation assignments, develop technical prototypes, and then implement the game including all programming and art. For the Fall 2017 offering of the course, we were interested in focusing more strongly on the game design, pushing students to experiment with the design beyond simpler modifications of known game genres and mechanics (game rules that allow the player to do something in the game [11]).

This is important not just to push the students to engage more deeply with the material, but also because it is essential for the field to continue to explore the space of possible games. There is a familiarity with known genres that make them appealing for students (and even professional game designers) to gravitate towards, but with the challenges facing the game industry regarding representation and diversity issues, it is especially vital for the next generation to introduce new ideas, genres, and mechanics into the field. This is challenging to teach in a one-semester course, but supporting experimentation is one way to address this.

In Fall 2017, we pilot tested a methodology we hypothesized would facilitate truly experimental game design. Our "participants" consisted of a group of twelve students in the course who had requested to work on an experimental research-based game which they called *Celestial Harmony*. The game uses a piano keyboard with a MIDI (Musical Instrument Digital Interface) output, which the computer interprets as a controller, and is used to control the game. They were given latitude in what game they created, although we gave them two design directives:

1. The game needed to be designed such that it would not make sense to play with any other controller; the controller should be an important part of the game design (e.g. it should not be an endless runner game with a piano keyboard instead of a computer keyboard as the controller).

2. The game should not be about the playing of the piano, although the piano should be incorporated into the game (i.e. it should not just be *Rock Band* [12] for the piano).

Because of the novel controller and the design directives, the game's design was forced beyond known genres, creating a new type of game experience. Likewise, because the game was experimental, it also functioned as research, teaching us more about how controllers influence and constrain the game design process.

This paper focuses on the instructor's role as facilitator and learning partner in an experimental game design course, describes the pilot study conducted with one group of undergraduates and the experimental game, *Celestial Harmony*, they produced, and identifies techniques that helped to turn the capstone course into a safe space for student experimentation.

2 Teaching Experimental Game Design

The ultimate goal with experimental design is to push boundaries and expand the knowledge in the field. For game design, this means showcasing the game at festivals or exhibits celebrating such achievements. In a classroom setting, this means providing students with the opportunity to try innovative new game styles, controllers, themes, etc. with lowered consequences for failure. Like experiments in the sciences, a "failed" game can inform the field just as much as a "successful" one – though the definitions of success and failure are more fluid.

It can be difficult to balance student agency in the creation of an experimental game while also ensuring that the game meets the design needs (in this case, research needs). In our case, mentoring faculty had to find a way to guide students so that they paid attention to the unique affordances and constraints of the controller and integrated them into the game's design. Laurillard suggests approaching teaching as a design science, constantly assessing and iterating the learning tasks [13]. Project- and problem-based learning curricula often encourage students to work in cycles of design, feedback, and revision [14]. These theories steered the changes in the course production milestones and format, so we could ensure integration of this nonlinear nature of design and learning.

As partners in learning, the mentor and the student designers may both experience discomfort from the uncertainty of experimental design. In our experience, the students struggled with the lack of grounding and context that they were used to leveraging from working with known genres and existing games. To address this on the student side and incorporate space for experimentation and feedback cycles, we emphasized conceptual and pre-production work through rapid iteration and prototyping. This allowed the students to create a large number of ideas and then, based on general feedback, refine their ideas to a select few. From there, we provided more in-depth feedback until a single idea was chosen and they could move into a production phase.

Emphasizing the earlier, preproduction stages requires less upfront effort and led to less work lost when the design invariably and radically changed early on in the semester. Rapid prototyping is a common design concept used in the MDA framework [15]

and discussed in depth by Brathwaite and Schreiber [16]. It is particularly valuable for more experimental design because there is no known genre or set of mechanics to provide a framework for the new design.

This process can also cause discomfort from the mentor side because unlike non-experimental work in which answers to common questions can be learned ahead of time and mitigated with lecture or prior planning, there are many questions that arise that cannot possibly be pre-planned for, as even the facilitators were not in control of the project's ultimate direction.

This was addressed in part by preparing the students ahead of time to let them know that we would not have all the answers, and in many cases would be learning alongside them. Effective instructor feedback is crucial in any project-based learning assignment [14]. It is our experience that experimental design requires a great deal more feedback throughout the process than more typical game design projects, as the students are less confident in their abilities and not used to coursework that lacks concrete requirements. To address this, we gave the students extra opportunities to meet with us so that we would have more opportunities to check in, answer questions and concerns, and share what we had also learned. This allowed us to bring a greater depth of experience to the group, providing insight and mentorship—which seemed to reassure the students when they sought feedback.

3 Celestial Harmony: A Pilot Study

Fig. 1. Two players at EduX 2018 working together to bring the temperate biome back to life in *Celestial Harmony. Photo credit: Deana Isabel.*

One way to help novice experimental designers engage in experimental design is by requiring the game to utilize an unusual controller. This forces the design to go beyond existing games and focuses the game design on the affordances and constraints of the

Fig. 2. A screenshot of *Celestial Harmony*, in which the player is interacting with the Arid biome.

new controller. It has long been understood that the physical controls for a game affect the game design and what types of games can be played [17], and the impact that the use of unusual interfaces has on game design is a subject of interest for several researchers [18][19][20]. For example, when using a piano keyboard as the controller, few common game genres make sense—a first-person shooter or endless runner would be ill-conceived in this format.

Every semester for the Game Design Workshop, the students nominate a verb (e.g., grow, explode, hide) as a possible theme for the games designed in class that semester. Once everyone has nominated a verb, the class votes, and the winning theme must be incorporated into each of the games created that semester. We use verbs as they map to game mechanics well and keeps the theme from being something that is used in a shallow or aesthetic-focused way. For this semester, the theme was "create." In addition to the theme, each game had to include a game mechanic that was not combat or movement related.

For this pilot study, a group of twelve undergraduate senior students created a Unity-based game called *Celestial Harmony*. As mentioned above, the game was built around the design guideline that the game should strongly integrate the MIDI piano in such a way that the game would not make sense to play with any other controller, integrate the notion of "create" in some way, and involve a non-combat and non-movement mechanic.

The final iteration of the game has the player take the role of an alien being who is traveling through the universe. On these travels, the player character finds planets that have died, and through the use of musical *creation*-based magic, brings the planets back to life (Figure 1). Each planet is made up of 4-8 biomes, and each biome has a particular set of spells that must be played to revive it. The spells are broken up by elements – earth, water, and fire – which are cast when the interactor plays a specific chord (Figure 2). Each element has 2-3 melodies that map to a specific spell—for instance, the water

element has ice, water, and rain as possible spells. The spells that revive the biome are based on the properties of that type of biome. For example, the jungle biome is revived by playing heat, rain, and plant spells in any order. There is a simplified *Mastermind* [21] mechanic that helps guide the players towards the appropriate spells to revive the biome and subsequently the planets.

There were three other games created during the semester. The first was a zombie horde game in which the player character was slowly turning into a zombie. The player fought their way through the hordes of zombies to gain items that were combined to *create* a cure. The second game was a wave defense game, in which the player had to survive against waves of mutated sea creatures for long enough that they could be saved. The player was able to *create* two defense towers that would aid them against the swarms of enemies. The final game's objective was to escape a factory where the player character was trapped. This game allowed the player to *create* different combinations of grenades which they could use against waves of enemies.

While the theme for these other games was creation, all of them still relied primarily on destructive game mechanics. In our experience, this is typical of many game design classes and workshops, where the students fall back on games they have played before as a way to contextualize future work. Changing the controller disrupts this tendency, as they are not able to rely on previously played games. This leads to a more open mindset regarding experimenting with new types of designs and mechanics, as evidenced by the novelty of *Celestial Harmony:* of all the games created in this section, this one most deeply incorporated the theme of creation.

Through the process of designing and creating *Celestial Harmony*, the group prototyped a number of different game mechanics and game genres, ranging from a planet building simulation to a dragon flying game. Due to the short timeline, the group was required to create and address these concepts and prototypes very rapidly, which, as mentioned above is a method advocated by game designers [16]. The students therefore were able to learn through trial and error and gained a better understanding of how the mechanics of the game were influenced by the controller and how this needed to be incorporated into the game design.

One example of this type of learning was seen in an early version of the game design that used a spell book that the player could access to see what to play to bring the biome back to life. However, this required memorization of the melodies, which turned out to be difficult for most players. Additionally, it meant that the only real challenge in the game was recalling which keys to press—focusing the player's efforts on the controller itself rather than allowing the keyboard to feel playful and integrated into the game. To counteract this, the group modified the game so that the player needed to guess which spells would bring the biome back to life, while using graphical cues to show the player what keys to press in what order for the different spells. This shifted the challenge to be about solving the puzzle of what elements would bring the planet back to life and minimized how punishing the controller felt in the earlier version.

While the course was only 15 weeks long, the game underwent three major revisions and five more minor revisions as the students worked through the design challenges and refined their game ideas. Given our own experiences as experimental game designers, this is typical of game design when working outside the boundaries of known game

genres and standard mechanics. With this level of iteration, prototyping plays a vital role in the class structure.

To accommodate this, the class structure was modified to use the following milestones (listed in order of assignment):

- concept pitches
- paper prototype
- documentation (game design document, technical design document, and art style guide)
- technical prototype
- vertical slice (proof-of-concept)
- alpha (early version of the full game)
- RTM (release to manufacturing)
- post-mortem (reflective paper)

While many of these are common assignments for a game design course, they also correspond with many of Mergendoller et al.'s Project Stages of Project-Based Learning, which makes sense because the design of experimental videogames is, by definition, an "ill-structured problem" [22]. These scholars organize the management of project based learning into stages. *Stage 0: Project Planning* is the main lesson planning phase. In this stage, the educator thinks through the design of the project, ensuring it will engage students in constructive learning activities, and that the scope and timeline are appropriate for the course. This phase is also the time when the driving question for the project is articulated, goals and standards for the project are decided, and resources are organized. *Stage 0: Project Planning* was carried out primarily by the facilitators prior to the start of the semester.

The second of Mergendoller et al.'s Project Stages is *Stage 1: Project Launch.* This phase takes into consideration student motivation and expectations. *Stage 1* defines project and behavior expectations, procedures, timelines, and grading policies. The bulk of *Stage 1: Project Launch* was handled by the syllabus and discussion in the initial course meetings, and much of this paper focuses on this stage, as it is crucial for effectively facilitating experimental game design in a classroom setting.

Stage 2: Guided Inquiry and Product Creation is when the student inquiry is actively conducted. This is where the instructor's role becomes most like a facilitator, helping subtly and only as needed to facilitate use of resources, assist with task definition, and assess student progress. In our pilot study, this stage aligned with the assigned concept pitches, paper prototype, and documentation assignments. Each milestone was treated as a formative assignment with a critique, providing timely and valuable feedback that focused the students' attention on their progress, and was specific, following Black and William's recommendations [23]. Students new to experimental game design require a great deal of feedback, and this guide also describes a few modifications made to the course to accommodate this need.

Stage 3: Project Conclusion is comprised of the presentation and assessment of the project as well as reflection on the project and the steps that learners took to complete it. Metacognitive reflection is especially important in this phase, as it has been shown to increase long-term retention. This final stage included the RTM milestone, which

was the final summative grade worth the most points, as well as the post-mortem, which gave the students a chance to reflect on what they had learned and accomplished throughout the semester.

The finished game won Best Use of Gameplay Mechanic at the Indienomicon Second Annual Indie Awards and has been showcased at Indienomicon, Otronicon, and EduX. This external recognition serves to reiterate to the students that their game was, in fact, successful not solely due to its novelty.

4 Field Guide for Encouraging Experimentation

Through our pilot study, we found some methods for encouraging experimentation worked better than others. Given the early pilot study stage of this study, the data analyzed to create this field guide predominantly consist of recollection and field notes. In this section, we address what we identified to be particularly successful and what we plan to carry forward in future iterations of the class, as a field guide of sorts for instructors looking to facilitate similarly experimental course projects. We were able to create a safe space for experimental game design with undergraduate students in the capstone course by modifying the grading of schema, encouraging rapid prototyping, and by providing frequent feedback.

Modify Grading

One of the biggest hurdles with introducing experimental game design to the capstone experience was the anxiety it caused students who were worried about creating a portfolio-worthy final product that they felt would, along with a high GPA, ensure well-paying employment after graduation. To address this, we began by modifying the grading schema. Students in the pilot study group were very concerned about their grade, given that with experimentation and research, there is no known right answer of what works or does not work, and they were wary of being penalized for not creating the "right" product.

To alleviate any potential grading discrepancy between the experimental group and the other groups in the capstone game design course, we changed the rubrics to include a section on the creativity and experimentation level of the project. This gave the students a chance to earn back points that they may have lost due to the challenges they faced in achieving a smooth game design. Likewise, students in the other groups who were not undertaking such vast experimental designs and chose "safer" genres earned fewer points in the creativity component but more points in the functionality of their game, so the pilot group was not graded differently than the other groups, maintaining fairness throughout the course.

In future iterations of the class, we plan to further alter the prototyping assignments to be even more strongly formative (fewer points and assigned even earlier on in the semester) to encourage experimenting early. We feel this will more effectively foster a culture of experimentation among more of the students in the course.

Encourage Rapid Prototyping

In game design, one of the best ways to experiment is through prototyping, specifically, rapid prototyping [16] using paper and other inexpensive physical materials to quickly create some aspect of the game for testing. The cost and time for these prototypes is minimized compared to creating the functionality in code.

To encourage this, we restructured the class to heavily use prototyping in the earlier half of the semester. In previous offerings of this course, the first assignment was a documentation milestone, including a game design document. We found that students often treated this document as a "Bible," and that they were unwilling to change or adapt the game in any way after they began building it. For this offering of the class, we instead assigned high-level concept documents for *three different* game designs in the second week of the course. This meant that the students had to put time and effort into at least three different ideas, an approach that helped to move them past being fixated solely on their first idea for the entirety of the course. Each group presented their three concepts to the class, and the other teams had a chance to critique those ideas and suggest new ones. This activity encouraged peer-to-peer feedback, another key feature for effective learning [23].

From there, the students worked to choose an idea that could be one of their initial three concepts, something mixed between them, or something new entirely based on feedback. They made this selection and created a paper prototype of the game which they then playtested. This allowed the students to very quickly get feedback on what was working and what was not, so they could modify and test again. It was not until after this step that the documentation assignments were due, and production began.

The heavy reliance on prototyping and testing gave the students room to be more experimental before entering the production phase of game development. This allowed all of the students in the course a chance to try out ideas before becoming committed to them—something that is rather uncommon in semester-constrained courses where students are required to produce full-fledged videogames.

Provide Frequent Feedback

Frequent, formative feedback is a vital component of student-centered learning, and research suggests that most students need opportunities to decipher and process external feedback [24]. Therefore, the last change we made was to increase the number of meetings we had with the students. In the course, the students follow Agile development methods, which are formed around iterative and incremental development and emphasize collaboration more than traditional hierarchical (waterfall) project management methods [25]. Within this project management organization, there are specific responsibilities assigned to each group member, and there is typically one Scrum meeting (group discussion of the progress being made) each week with the instructor. The producer (lead) for the team takes the role of ScrumMaster and each group member reports their progress and receives feedback. For this class, we offered an optional second weekly meeting with the instructor as an opportunity for additional feedback. While few of the other groups attended this extra meeting time, the experimental group took advantage of the opportunity, especially at the beginning, as a chance to for extra guidance when they were struggling with the design.

Additionally, we offered all groups the option to include us in their group's chat channels (Slack or Discord). Again, the experimental group took us up on the offer, meaning that we were available for quick answers to questions about design or research, although we left the channels muted, with alerts to notify us when we were addressed by name, to allow the students to not feel like they were being constantly monitored.

Students in the pilot group also sought additional non-instructor feedback. Generally, in the capstone course, there are three playtesting sessions in the course to give each group an opportunity to learn first-hand about how people outside of their group play the game. The pilot group set up their own playtesting sessions and conducted playtesting on *Celestial Harmony* every week, as they needed information about how people would interact with the novel controller. This consistent feedback informed each iteration and helped the group understand how players unfamiliar with the game approached gameplay, apprising the group about particular aspects of the user experience, such as where tutorials or other playing guides were necessary. The feedback provided by this frequent playtesting of each iteration of the game proved to be so beneficial to the design of the game that we intend to incorporate more opportunities for playtesting in future offerings of this course.

5 Conclusion & Future Work

Overall, we found that our pilot study was a success, and that it is possible to include experimental game design into a game design capstone experience. It did require some modification of the course and how we interacted with the students to support the opportunities and challenges of experimental design.

We were able to create a safe space for students to conduct truly experimental game design within a capstone course. We did this by making adjustments to the grading schema to add a creativity and originality score so that the students would not be penalized heavily for experimenting. This alleviated a great deal of student anxiety over potential failure. Future work to more fully assess the efficacy of this step is needed; perhaps an anxiety assessment at the beginning and conclusion of the course or even semi-structured interviews with project groups or individual students could shed additional light on this aspect of the intervention.

We also encouraged rapid prototyping, which helped students iterate on their ideas and not feel as if their first ideas were "set in stone." This helped not only our pilot study group, but the other groups in the class as well. Finally, we found that frequent feedback was key. We doubled the number of instructor-group meetings—though the additional meeting times were optional, the pilot group chose to attend most of them. The students themselves sought additional external feedback by holding weekly playtesting sessions, which proved immensely beneficial and could also be integrated into the structure of future courses.

This initial, small pilot study was in and of itself a design experiment focused on instructional design. This pilot study was successful in that the students were able to design a game that not only pushed the boundaries in which the established game genres

currently exist, but also earned recognition from external organizations designed to recognize excellence within the game industry.

In the future, we would like to offer the class with all groups participating in experimental design. This would give us a broader base of understanding of how the students engage with and learn from experimental design and allow us to refine how we structure the class to support it. Scaling this fully to a section containing four to eight groups of 10+ students may prove to be excessively time-consuming, if each group elects to include the instructor in their chat group and requests feedback often. However, the other suggestions offered in this field guide can be effectively applied to larger courses with multiple groups with minimal additional time cost to the instructor.

Beyond the game design curriculum, we believe that the field guide and lessons learned presented in this paper could be applicable to other fields with experimentation at their core. A creative writing course, for example, could benefit from a similar "safe space" for experimentation and failure, perhaps emphasizing the blurring of genres or experimenting with narrative structure. Similar experimentation could likewise be incorporated into courses in the arts and other humanities subjects.

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