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WIP: Statics in Space - Developing a Dungeons and Dragons Inspired Statics Course

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WIP: Statics in Space - Designing a Dungeons & Dragons-Inspired, Space-Themed Statics Course

Introduction

The purpose of this WIP paper is to explore a gamified course design for engineering statics. Engineering statics–herein referred to as statics–is the first computational engineering course students take in their second year, typically in tandem with physics and calculus. Engineering students are most likely to drop out of their engineering programs after taking statics, leading it to be considered a "weed-out" course [1], [2]. Factors that may affect student attrition from engineering programs may be due to lower grades earned in statics, lack of support, and the "chilly" climate of engineering [2]. To address the high attrition rate, engineering education researchers have conducted extensive research on student motivation and demonstrated that higher motivation is linked to a higher chance of persistence [3], [4], [5], [6], [7], [8]. Student motivation can be increased by implementing pedagogical practices such as active learning (as opposed to passive learning from pure lecturing). Our research explores the use of the gamification of learning pedagogical framework to teach engineering statics and how it may increase student motivation and persistence. Our objectives for this paper are to share our initial game design and methods for development.

Current Engineering Statics Course

At Utah State University, engineering statics is offered every semester with three sections in the Fall semester and two in the Spring semester. The three faculty who teach a section of statics created eleven shared technical knowledge objectives and four skill objectives (as shown the Appendix). The engineering statics course taught by Dr. Marissa Tsugawa currently contains active learning and project- and problem-based learning elements. Dr. Marissa Tsugawa's course activities include completing practice problems (homework that emphasizes practice), understanding checks (an accountability measure to ensure students are learning the content), discussions (connect content to the real world), module assessments (open-ended questions received multiple times), and a project (design, build, and test a spaghetti bridge). The current design of the course can be easily mapped to a gamified course.

Gamification of Learning Framework

Gamification is most commonly defined as "the use of game design elements in non-game contexts" [9] and is referred to as the gamification of learning in classroom environments. Gamification of learning can take the form of either partially gamified learning units and learning activities, or a fully gamified course structure [10]. Within gamification and our previous work, we have outlined four game components to be included when designing a gamified learning activity as described in Table 1 [11], [12], [13].

Table 1. An outline of game elements and how they relate to the game-based learning unit

Game Component	Definition	Example
Game Goal	The objective of the game	Reaching the finish line (MarioKart) or collecting the most money (Monopoly)

Game Dynamics	What the players must do to accomplish the goal	Exploration interaction (finding things of value in the game), Solution (solving a problem or puzzle in the game).
Game Mechanics	The rules of the game and how players interact in the game	How players 'take turns' during the game, competition vs collaborative games, point systems and rewards, etc.
Game Elements	The "look and feel" of the game	Game aesthetics and game theme

Gamification has been linked to motivational theories such as Self-Determination Theory (SDT) because of the extrinsic motivators (such as points, badges, and leaderboards) and intrinsic motivators (such as group work and autonomy) provided in gamified environments [14], [15], [16]. More specifically, the game design we intend to implement involves the use of intrinsic motivators such as stories, challenges, and avatars to enhance self-reflection skills [17]. This style of play further aligns with our research goals which is to shift the focus of coursework from numeric grades and scores, to self-reflection and learning the course content [18], [19].

Theoretical Framework

We leverage the motivation framework self-determination theory (SDT) to inform our course design and measure the course efficacy during implementation. According to Ryan and Deci [20], SDT explains how people develop a sense of self while engaging in social contexts such as work, education, and other social structures. SDT focuses on three basic human needs, the need for competence, belonging, and autonomy. Competence refers to the feeling of effectiveness within social contexts and relationships, as well as the ability to exercise their capacity for knowledge within their environment. Belonging refers to feeling connected to others and the sense of belonging within the social context or community. Autonomy refers to the ability of an individual to express themselves in ways that align with their core values. We will design game elements to support each construct of SDT.

Game Design: Initial Concept

Our design for a space-themed statics course is inspired by the video game *Heavenly Bodies*, the role-playing game *Dungeons & Dragons*, the university's emphasis on and student interest in aerospace engineering, and the Engineering for One Planet framework [21]. While *Heavenly Bodies* and *Dungeons & Dragons* inspired our gamified course, students will not be required to have experience in either game as we will explain the rules during class. Furthermore, some literature suggests that students think gamification is an engaging form of learning regardless of their prior gaming experiences [22]. Based on the learning objectives from Engineering for One Planet, the gamified course will expose students to environmental and social sustainability and systems thinking. Students will develop skills such as teamwork, communication, problem-solving, critical thinking, and environmental assessment. Finally, students will also explore ethical and technical problems. Our game design process includes identifying game goals, elements, dynamics, and mechanics and connecting them to the technical knowledge and skill objectives for statics.

Game Goals

The overall goal of the gamified course is to maintain the environmental and social balance of a lunar base (e.g., water levels, waste production, food production) by completing technical and ethical challenges throughout the semester. Smaller objectives to meet the goal will connect to the technical knowledge objectives of the current statics course. For example, students can analyze the water level using hydrostatics and conduct methods of joints and sections to machines used in the base (e.g., a potato harvester, robot arm) and design a truss. The students will work in teams and be responsible for different sectors of the lunar base. The teams will have to communicate with one another to ensure their solutions will not affect other teams' sectors of the lunar base. The outcomes of their decisions may alter the course of the game such as creating another challenge when there is a failure or receiving a resource to use later in the semester.

Game Elements

The game elements will include a space theme, narrative elements, character building, and collaboration. The game themes and problem-solving activities are based on the video game *Heavenly Bodies* in which students must work together to solve both ethical and technical problems in space. Specifically, our initial game concept involves students operating a lunar base that contains multiple sectors needed to maintain a community on the moon (e.g., waste, water, energy, cafeteria, sleeping corridor, potato farm). A student group will be assigned to each sector of the lunar station where the groups will need to communicate with one another when making decisions based on calculations that could affect other sectors. For example, students may face technical problems such as fixing a satellite truss bridge (see Figure 1 for example), and they may also face ethical problems such as mining and resource sharing in outer space. We also anticipate using game elements similar to those of *Dungeons & Dragons* such as character building, collaboration, and narrative elements. We chose these types of elements so that students could foster a sense of community, as well as develop collaborative skills, and self-reflections skills [17], [23].

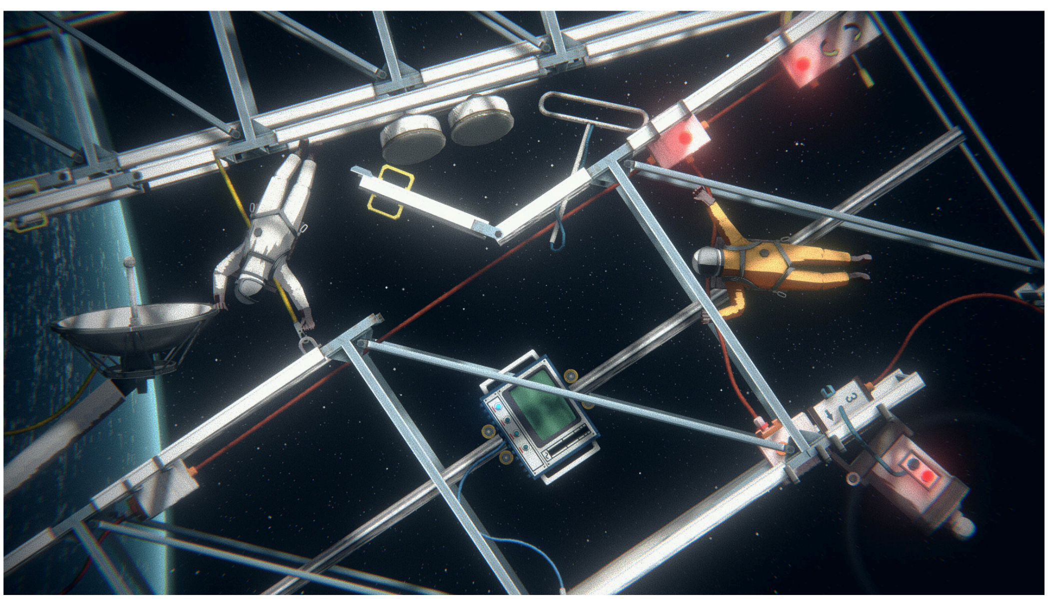

Figure 1. An example of fixing a truss satellite from the game *Heavenly Bodies*

Game Mechanics
In the gamified design, we will sort students into teams where they must collaborate both within their team and with other teams to solve technical and ethical statics problems relating to space. We chose a collaborative game environment instead of a competitive game environment because research shows that using collaborative elements enhances problem-solving-based simulations and allows students to construct knowledge together [24], [25]. In engineering contexts, this collaborative environment supports national standard student outcomes and supports the skills the engineering industry would like to see from graduating engineering students while exposing students to ethical, environmental, and sustainability issues [21], [26], [27].

Game Dynamics
In this game, we will use narrative storytelling as a guide to collaborative efforts within the game. In the statics course, we will follow two core game dynamics to support the game goals and mechanics, we will use exploration and construct/build dynamics [13]. The exploration game dynamic will be used to explore resources and ethical issues within space. Exploration dynamics are typically used in the classroom for activities involving gaining informative knowledge and analysis [13]. However, this dynamic will be combined with the construction/build game dynamic which involves the problem-solving process using limited resources [13]. For example, in this course, students will come across ethical issues such as resource sharing either food, water, farming, or mining in space.

Grading & Assessment Within the Game

Throughout the game, we intend to use equitable grading practices that follow three pillars: mathematically accurate, bias-resistant to subjectivity from a student's culture or family background, and motivating for student success [19]. These three pillars are meant to take student focus from the letter grade they would like to achieve to the learning objectives and self-reflective progress throughout the semester [18], [19], [28], [29]. Further, we will leverage feedback, assignment resubmission, and self-reflections on learning progress. Students are often left out of assessment design, so their feedback will be vital.

Methods

In this study, we are initiating a participatory design process where students will provide feedback on the course design. Participatory design is a methodology that is both product or design-focused and participant-focused, meaning participants play an active role in the research process [30]. However, Cumbo and Selwyn [31], point out that in educational contexts, the participatory design must be modified from its original Scandinavian roots. In educational spaces, the participants or students cannot fully participate in the research process as they cannot modify learning outcomes. Instead, they can influence the pedagogy used in the classroom based on their feedback. This modified participatory design method is meant to empower students in the classroom as they learn complex problem-solving skills [31].

Prior to receiving feedback from students, we will first collaborate with a professional game designer to develop an initial outline of the gamified structure. As we outline the structure, we will ensure that we are aligning the game goals with the learning outcomes of the statics course.

We will also develop preliminary activities and a preliminary Canvas course for students to review in focus groups.

Upon receiving institutional review board approval, we will invite 10 - 15 students to provide feedback on the initial course design and suggestions for what they would like to see in a gamified course. These students must be currently enrolled in or have completed the statics course. Students will be invited to provide feedback on the current course structure and the initial game design ideas before implementation in the Spring 2026 semester. Based on this feedback, undergraduate teaching assistants, a graduate teaching assistant, and the PI and Co-PI on the project will discuss the feedback, and provide details on the fully gamified course design to be implemented in the Spring 2026 semester.

During the Spring 2026 implementation of the gamified course design, we will ask students to provide feedback on their learning progress and ask for suggestions and feedback on the initial game implementation. This way, we still include student input into the participatory design process.

Timeline

The timeline for this project is as follows in Table 2 below.

Table 2. A timeline of the preliminary design process

Task	Start Date	Completion Date
Brainstorming with game designer	Jun 2025	Aug 2025
Outline course structure	Jun 2025	Jun 2025
Connecting game goals with learning objectives	Jun 2025	Jul 2025
Creating activities	Jul 2025	Aug 2025
Developing the Canvas page	Jul 2025	Nov 2025
IRB submission	Aug 2025	Aug 2025
Recruit students for focus groups	Sep 2025	Sep 2025
Review the course outline with focus groups consisting of current students and teaching assistants	Sep 2025	Sep 2025
Train teaching assistants	Oct 2025	Nov 2025
Implement feedback from the focus groups into the current game design	Oct 2025	Dec 2025
Implement game design into the Statics course	Jan 2026	May 2026

Summary

This WIP describes our initial design for a gamified engineering statics course. Our gamified course challenges students with a space theme where they need to consider ethical and technical decisions to maintain the environmental and social balance of a lunar base. We have a foundational premise of the gamified course and connect learning objectives to the Engineering for One Planet framework [21]. The next step in our design process is to use participatory design research where we involve students in the design process. This approach allows stakeholders to make decisions toward the final product. We aim to share an example lesson from the gamified course during the conference to receive feedback from other instructors. In this work in progress, we aim to ask feedback questions to the audience: What are the barriers to implementing gamification for you? What kind of games would you be interested in implementing in your course? We also look forward to discussions about equitable grading practices and course efficacy measures.

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Appendix

Technical Knowledge Objectives

1. Identify and apply vector/scalar operations
    a. (e.g., addition, subtraction, parallelogram law of addition, triangle rule, dot product, cross product, triple product)
    b. to solve and express (consider right hand rule and CW or CCW convention as demonstrated in Hibbeler's text and tying to his datum) forces and moments and determine angles between them and to the primary axis of a coordinate system.
2. Develop an understanding of how physical phenomena create forces and moments on statics objects (AKA engineering sense)
    a. Types of forces
        i. contact forces: such as normal, frictional, tension, applied, and spring forces
        ii. action at a distance forces: such as gravitational force (weight)
    b. Distributed loads and locating their equivalent force location
        i. Intensity
        ii. Pressure
    c. Moments
        i. From Couple,
        ii. from force about an axis
3. Recognize, interpret, and create an accurate Free Body Diagram (FBD) of a particle and/or rigid body
    a. include and label appropriate force vectors, moment vectors, coordinate system defining the positive axis, dimensions and angles
4. Understand and apply the concept of static equilibrium based on Newton's Laws of Motion
    a. to help solve for forces/moments/couples by developing equations for equilibrium along 2D or 3D axis systems in an FBD.
    b. to identify and solve static concurrent, coplanar, parallel, and wrench force systems
    c. to solve distributed loads into equivalent point loads and calculate where they should be applied to a rigid body. Solve pulley and block and tackle problems.
    d. to identify equilibrium and correctly analyze unknown forces, moments, or angles using 3 or more equations with 3 or more unknowns.
    e. to understand static determinacy and identify redundant or improper constraint in 2D and 3D problems
5. Inspect constraints on a rigid body and apply the proper calculated reaction forces and moments for both 2D and 3D systems.
6. Recognize 2 and 3 force members in a system of connected parts that have been analyzed under static conditions.

    a. Show and understand the proof of a 2-force member system and describe the advantage of its recognition in frame and machine problems.
7. Apply static equilibrium to complex structures
    a. discuss how forces transfer through connections found in trusses, frames, and machines.
    b. Identify typical truss configurations and truss components
        i. Identify zero and two force members in the truss
        ii. recognize the assumptions for a system to be classified as a truss.
    c. Determine the tensile or compressive forces in truss members applying
        i. the methods of joints
        ii. the methods of sections
        iii. both the method of section and the method of joints
    d. Identify a frame or machine
    e. Determine the forces and moments present in a frame or machine components
8. Apply static equilibrium to hydrostatics
    a. to calculate pressure, intensity, and force on a variety of surfaces at given depths
    b. determine overturning moments on gravity dams.
9. Apply static equilibrium to solve for internal forces
    a. identify and explain the relationship between loading, shear, and bending moment diagrams while also
    b. derive one diagram from the other recognizing typical relationships between them using calculus.
    c. develop equations to calculate shear and bending moment values at specific locations along beams.
    d. be able to discuss and apply the typical sign conventions used to reveal internal forces and bending moments at an imagined cut in the beam.
10. Identify different, physically relevant, possible solutions involving friction (conditional thinking) and determine the governing situation from accurate FBD and generated equilibrium equations.
    a. identify and discuss the advantages/limitations to the dry friction (Coulomb) model
    b. create appropriate FBD and equations of equilibrium for friction problems given a variety of impending motion scenarios (i.e. tip or slip)
    c. identify and apply the correct threaded friction formula to resolve for upward impending, downward impending, or locked conditions.
11. Identify, understand, and calculate geometric properties of rigid bodies using integration or composite body techniques:
    a. locations for center of gravity, mass, volume, centroids of area and lines

b. calculate area moments of inertia, area products of inertia, and mass moments of inertia around pertinent axis and discuss their importance to future engineering principles that will be learned in dynamics and mechanics and beyond.

Skill Objectives

The main skills you will develop over this course (described further in Evaluation Methods and Criteria Section below) include:

1. Engineering problem solving
2. Modeling systems
3. Communication and Professionalism
4. Self-regulated learning