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Fostering an Entrepreneurial Mindset in Systems Simulation

Michael E. Kuhl
Rochester Institute of Technology

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Michael E. Kuhl
Industrial and Systems Engineering Department
Rochester Institute of Technology
Rochester, NY 14623

Abstract
Simulation is tool frequently used by companies when designing systems to evaluate alternative system designs. In particular, simulation is employed when the dynamic behavior of a system is not well understood and the decisions that are being made have significant economic or social impacts. However, courses in systems simulation typically focus on the technical and statistical aspects of model building and the comparison of design alternatives focused on operational performance of the system (that is, performance metrics that can be collected within the simulation itself.) This paper investigates how an entrepreneurial mindset can be fostered through activities/methods that encourage students to look beyond the operational aspects of system design to the overall value and impact of design alternatives. The development, implementation, and outcomes of two KEEN modules are presented to demonstrate the integration of an entrepreneurial mindset in a systems simulation course.

1. Introduction

The entrepreneurial mindset concept has gained momentum in science, technology, engineering, and math (STEM) disciplines in recent years. Bosman and Fernhaber [1] define the entrepreneurial mindset as "the inclination to discover, evaluate, and exploit opportunities." Having this mindset is necessary to become a highly successful engineer. Although technical knowledge is fundamental to engineering design and analysis, an engineer also needs to be able to determine which problems to solve, generate alternative solutions, evaluate the value of the solutions, and find opportunities to innovate. Through engineering education, the entrepreneurial mindset can be encouraged by integrating this concept with technical content to produce highly effective engineers.

Educators and researchers have looked at a variety of pedagogical methods for developing this entrepreneurial mindset in students. Bosman et al. [2] present on-line discussions as a means to develop the entrepreneurial mindset. Serious games are used by Bellotti et al. [3]. In addition, Korach and Gargac [4] discuss the use of active learning exercises to introduce the entrepreneurial mindset to first year engineering students. Vignola et al. [5] apply project-based learning in an engineering statistics course. And, Burden et al. [6] demonstrate how the entrepreneurial mindset can be developed through a software engineering course. These are just a few of the growing list of examples of how students can engage entrepreneurial mindset within their engineering courses.

This paper investigates how an entrepreneurial mindset can be fostered in a systems simulation course. In particular, we develop activities/methods that encourage students to look beyond the operational aspects of system design to the overall value and impact of design alternatives. In

particular, the methods and activities in this work, were developed under the entrepreneurial mindset engineering educational framework put forth by the Kern Entrepreneurial Engineering Network (KEEN) [7]. In summary, the KEEN entrepreneurial mindset framework includes components of *curiosity*, *connections*, and *creating value*. These ideas coupled with the *engineering skillset* including *opportunity*, *design*, and *impact* can lead to *educational outcomes* for successful engineers. In the next sections, we discuss the development, implementation, and outcomes of two KEEN modules that demonstrate the integration of an entrepreneurial mindset in a systems simulation course.

2. Integrating Entrepreneurial Mindset Activities in Systems Simulation

When designing a system, companies frequently utilize simulation to evaluate alternative system designs. In particular, simulation is employed when the dynamic behavior of a system is not well understood and the decisions that are being made have significant economic or social impacts. (Examples include, design of sustainable production systems; design of hospital emergency departments, etc.) However, courses in systems simulation typically focus on the technical and statistical aspects of model building and the comparison of design alternatives focused on operational performance of the system (that is, performance metrics that can be collected within the simulation itself.) As a result, the boarder impacts and the value created under various alternatives may be overlooked.

To address this issue, as set of KEEN modules are being designed and implemented to foster an entrepreneurial mindset. In particular, the goal was to help students see how simulation can be used in system design to create value and facilitate innovation. In the next sections, two of these activities are presented. The first is an active learning assignment conducted in the first two weeks of the semester. The second is a project based learning activity that served as a midterm project for the course. The intent of these activities is to raise student awareness and apply their entrepreneurial mindset when conducting their term project during the second half of the course.

2.1 Activity 1: Simulation Everywhere!

The first KEEN module that we developed is titled, *Simulation Everywhere!* The objective of this activity is for students to discover the wide array of applications of simulation and to identify the significance of these applications. In particular, the assignment is designed to make students aware of the value of the role that simulation plays in solving problems throughout industrial and service organization.

The assignment is given within the first two weeks of the course as students are learning what simulation is, but do not yet have much experience with simulation modeling using simulation software tools or conducting simulation analyses. The assignment involved an individual and a group activity, as follows:

Individual Activity:

- Search the paper archive of the Winter Simulation Conference [8] (a leading conference on simulation) to obtain an application paper where simulation is used to solve a problem that is of interest to the student. (The paper archive of the Winter Simulation Conference is maintained by the INFORMS Simulation Society and is available on-line [9].)
- Read the paper and write your own one-paragraph summary that explains how simulation is used; the results/actions/improvements/conclusions/etc.; and broader impact (social, economic, societal, business, etc.)
- Be prepared to discuss your application with your assigned group during class in one week.

Group Assignment:

- In class (one week from the initial assignment), in groups of three students, discuss and select one application from your group.
- Create one visual-aid slide for the group's selected application.
- In class (in one week), one person selected by the group will give a 90 second summary presentation of the application to the class.

One of the objectives of this exercise is to get students exposed to a number of different application areas and to see the value that simulation can add in the context of the particular application. The individual assignment ensures that everyone actively participates provides a diverse set of applications to discuss. Since the students have very little exposure to simulation modeling at this point it is easy for them to focus on the application and the value of the solution rather than focusing on alternative modeling approaches. The group assignment enables the students to verbalize and explain their solution to their classmates while hearing about two other applications. Finally, the class presentations provide the students with exposure to more applications. In the fall semester, this activity was conducted with a class size of 39 students, so each student was exposed to at least fourteen applications. Figure 1 is an example of a visual-aid slide produced by one of the groups.

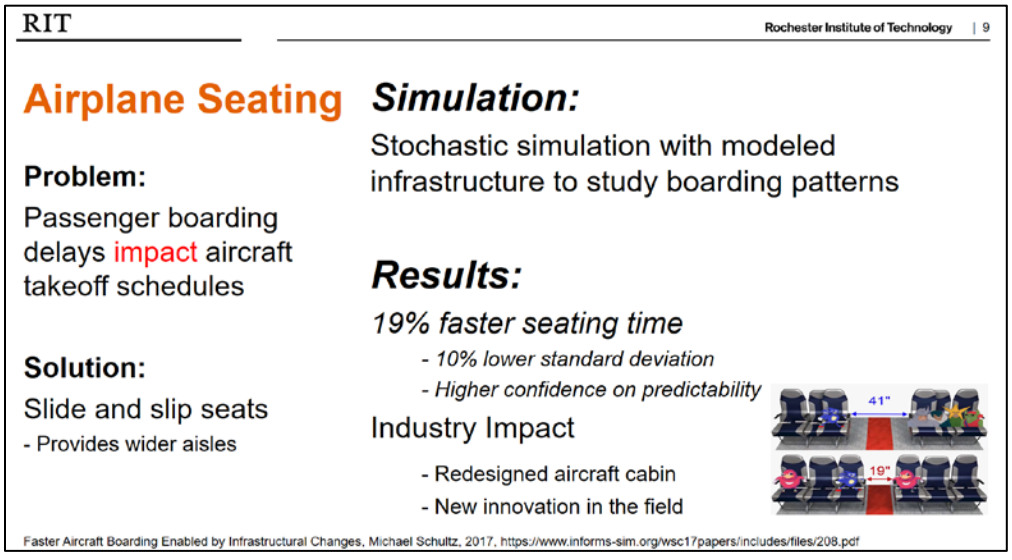

Figure 1: Example of a visual-aid slide of an application presented by a student group.

The airplane seating application shown in Figure 1 illustrates the entrepreneurial mindset being applied. Namely, the impact of the problem is clearly stated in terms of how passenger boarding impacts aircraft schedules. Further, the potential solution of the sliding seat is presented along with how simulation is applied to compare alterative systems. Finally, the operational performance measures and broader impacts are discussed in term of the potential benefits and impacts to the industry.

Overall, students were able to identify problems that existed in the application, how simulation was used, and how the simulation results were taken into account with the boarder aspects of the problem to aid in decision making and implementation.

2.2 Activity 2: Theme Park People Mover

The second activity used to encourage the use of an entrepreneurial mindset was a group midterm project. In this case, the students are given an open-ended problem. The objective is to consider value creation and broader impacts throughout design, analysis, and in forming recommendations. The particular exercise is designed around moving people among areas of a large theme park. The following information was provided to the students:

- Design a system to transport theme park guests between the lands within the Tiger's Den Amusement Park (TDAP). A conceptual diagram of the theme park is shown in Figure 2.

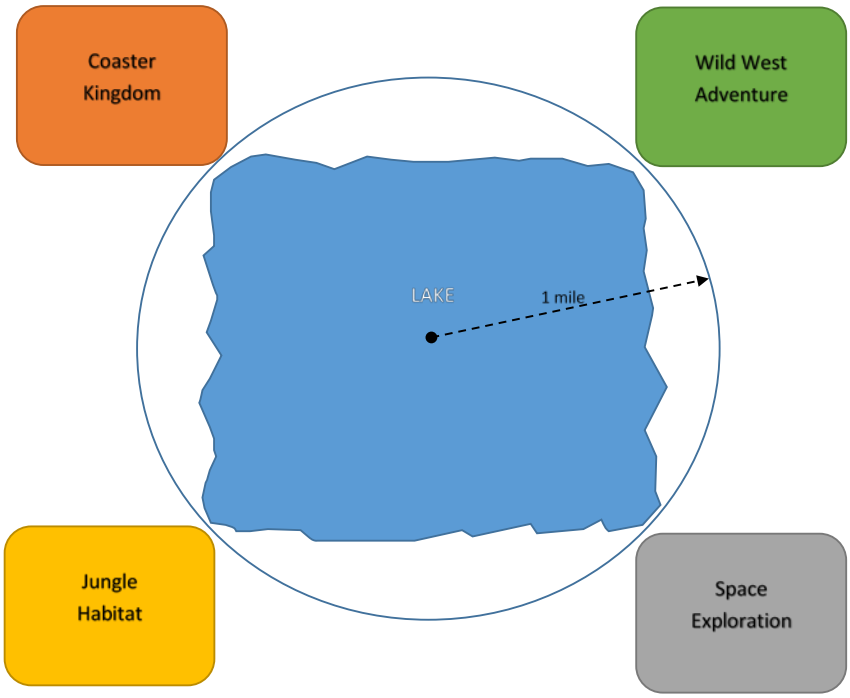

Figure 2: Diagram of the TDAP theme park.

- There are 4 lands surrounding a lake that has a radius of approximately 1 mile.
- The park is open from 9 a.m. to 9 p.m. each day.
- On average 400 guests per hour want to leave each land and travel to another land. The destination is equally likely to be any of the other lands.
- Guest travel in groups of 1-6 guests with the following probabilities (1(10%), 2(30%), 3(20%), 4(25%), 5(10%), and 6(5%)).
- The target date for operation is one year.
- The instructor will serve as the Chief Operating Officer (client and decision maker) for TDAP.
- Design and evaluate transportation system alternatives for the Tiger's Den Amusement Park (TDAP).
- Evaluation must assess the total value of the alternatives (including but not limited to initial cost, operational costs, operational performance, guest experience, and other factors.)
- You may estimate costs, times, etc. but cite sources. You may use the Internet, publications, etc., but you may not contact any person or business to get information.
- Thoughtful, specific questions to the COO about the park, transportation needs/wants, etc. are encouraged.
- Deliverables include a written report and class presentation.

This open-ended question allows for students to be creative about the potential solutions and to really consider the value that the solution will bring to the organization. Although busses may be an efficient way to transport people between locations, the guest experience will not be any different than riding a bus to school or to the market. In generating many creative solutions including boats, submarines, gondolas, trains, monorails, underwater tunnels/aquarium, among others, student were able to simulate how efficient the modes of transportation would be but also assessed many other factors including the guest experience or entertainment value, the impact of weather, accessibility for guests, safety, etc. By thinking through the value and innovation of the various alternatives, the groups generated some great alternatives. This assignment required that the students utilize aspects of the entrepreneurial mindset to achieve a successful outcome.

3. Outcomes and Assessment

The activities presented in the last section are two example of how an entrepreneurial mindset can be developed. In terms of the systems simulation course, the desired outcomes were achieved. In particular, as the students conducted their term project during the second half of the semester, the entrepreneurial mindset could be observed through the student reports and presentations. For the term project, students worked in teams (different teams than the midterm project) to use simulation to develop and evaluate alterative for an application (each groups is given a different application/problem). The deliverables for the term project are a report and a class presentation.

In previous semesters, students conducting these term project would focus almost exclusively on the system performance measures produced by the simulation models that they constructed. However, in this semester, student did a much better job of discussing the evaluation of alternatives

and their recommendations in terms of the overall problem, the value of the alternatives, and the broader impacts.

In terms of assessment, a rubric is currently used for the term project that includes aspects of the problem solving process. As the activities associated with fostering the entrepreneurial mindset are developed and implemented for the systems simulation course, rubrics are under development that contain specific expectations for evidence of how the entrepreneurial mindset was applied.

4. Conclusion

In conclusion, methods and activities for fostering an entrepreneurial mindset within a systems simulation course were presented. In particular, an active learning exercise and a project based learning exercise were discussed in terms of how they encourage students to develop this mindset. In addition, the desired outcomes were achieved as evidenced by the student's increased awareness of the value of their solutions and broader impacts in the term projects. Future work in this area will be to continue to integrate aspects that will develop an entrepreneurial mindset in other systems simulation class activities and assignments, and to develop rubrics that will explicitly measure the extent to which each student has applied this mindset in their work.

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