Teaching Simple Combat Models through Spike TV's "Deadliest Warrior"

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ABSTRACT

Combat models allow military analysts and leaders to analyze potential conflicts and evaluate different technologies and tactics. While there are a number of combat simulation packages available, they typically are intended for specific applications, while also requiring complex software that can be difficult to learn. As such, it is essential that military leaders and analysts are able to develop simple combat models to analyze conflicts out of scope of current simulations. To address this need, a course project was implemented in a combat modeling course at the United States Military Academy to teach students this valuable skill. This project was inspired by the show "Deadliest Warrior," which modeled a fictional conflict between two temporally and/or geographically displaced fighters (e.g., a Samurai fighting a Viking). The course project required students to identify two combatants and research their lethality and survivability. After conducting this research, each student built a stochastic model in Microsoft Excel to identify the percent of runs where each combatant wins. This project reinforced numerous principles of combat modeling, forcing students to perform background research, critically analyze the two warriors, make assumptions, build a stochastic model, perform verification and validation, and analyze the results. This paper presents the assignment, examples of products produced by students, feedback from students, and a compilation of lessons learned. Feedback from students was positive with most students indicating they enjoyed the exercise and developed a deep appreciation for the nuances of combat models. By requiring students to build simple combat models, the course project successfully taught a valuable skill essential for military leaders and analysts.

ABOUT THE AUTHOR

Dr. Vikram Mittal is an Associate Professor in the West Point Department of Systems Engineering. He holds a B.S. from Caltech in Aeronautics, an M.Sc. from Oxford University in Engineering Sciences, and a Ph.D from MIT in Mechanical Engineering. Prior to teaching at West Point, he was a senior mechanical engineer at Draper Laboratory. He has broad modeling and simulation research and teaching experience ranging from computational fluid dynamics, solid mechanics, chemical kinetics, energy consumption, and combat modeling. In his teaching capacity, he is the course director for the Combat Modeling course at West Point.

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INTRODUCTION

Combat models are essential tools for military analysts and leaders to evaluate potential conflicts, technologies, and tactics (Hill, 2017). While many combat simulation packages exist, they are often limited to specific combat applications and require complex software that can be challenging to learn. This creates a need for military leaders and analysts to develop simple combat models to analyze conflicts out of the scope of current simulations.

To address this need, a course project was implemented in a combat modeling course at the United States Military Academy. In this project, students selected two combatants and researched their survivability and lethality. They then built a model in Microsoft Excel to determine the percentage of runs where each combatant wins. The course project was inspired by the show "Deadliest Warrior," which modeled a fictional conflict between two temporally and/or geographically displaced fighters. By building simple combat models, the project reinforced principles of combat modeling, including background research, critical analysis of the warriors, assumption-making, model building, verification and validation, and result analysis.

This paper provides an overview of this project, including a summary of the model that students were required to create. It then provides an assessment of this project by looking at common issues, student grades, student feedback, and course end feedback.

SE485: COMBAT MODELING

Systems Engineering 485 (SE485) is a combat modeling and simulation (M&S) course offered at the United States Military Academy (USMA) that teaches students about the theoretical and practical aspects of combat modeling and simulation. The course covers a wide range of fundamental M&S topics, including the role of random numbers, probabilistic foundations of simulation, verification and validation, simulation experiment design and execution methods, modeling techniques, and analysis of results. The objectives of the course are given in Figure 1.

The course also focuses on teaching algorithms specific to combat M&S, such as target detection, shot delivery accuracy, and casualty assessment. The course has undergone several changes in software over the years. It was first developed in the early 1990s using JANUS, a tactical combined arms simulation. Subsequently, the software changed to One Semi-Autonomous Force and now currently to the Infantry Warrior Simulation (IWARS), an entity-based, multi-sided simulation program that focuses on small-unit Army accredited operations.

IWARS is powered by a detailed database that captures the associated parameters and has an intuitive user interface that allows students to become proficient in using it after 10 to 15 hours of lab exercises. However, SE485 quickly became known as the "IWARS class" as students felt that the primary objective of the course was to learn the software.

The course was structured into three parts. In the first part, students learn the methodologies that underly combat modeling. From there, they learn IWARS through a series of structured tutorials. The final block of the course has students perform analysis in IWARS to assess new technology on the battlefield. Each block in the course is tied to a project. Figure 1 displays the course structure and the mapping to these course projects. The first project focuses on methodologies where students build a simple, stochastic dueling model in Microsoft Excel. The second project has students rebuild the first project in IWARS; they then expand the project to include a more complex mission set. The third project has students build out a complex combat simulation in IWARS that incorporates new technologies.

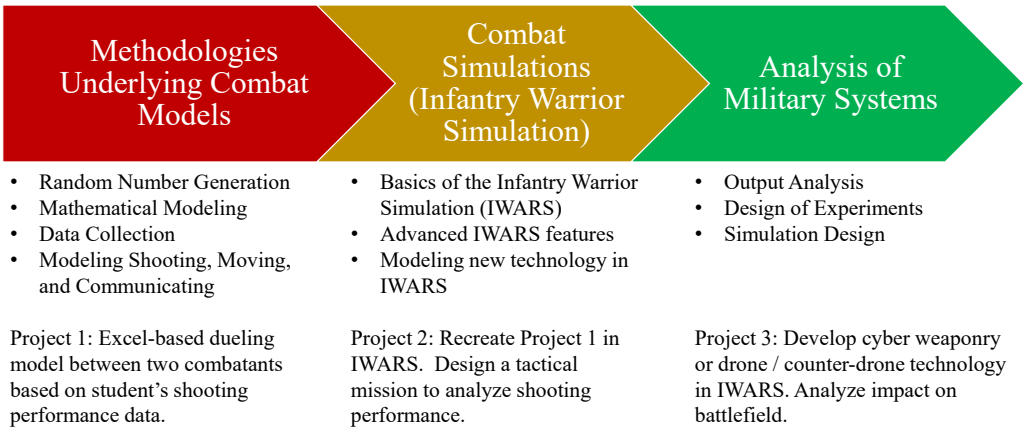


Figure 1. Structure of SE485: Combat Modeling, including the projects tied to each major block of instruction.

SE485 has followed this general format and structure since 2010 and continues to follow this form. However, in 2018, a new project was introduced at the start of the semester. This new project, which is detailed in the subsequent sections, was loosely based on Spike TV's "Deadliest Warrior" television show. The project was handed out during the first lesson and due two weeks later. The goal of the project was to pique student interest in combat modeling while also introducing students to the process to design and analyze a combat model.

DEADLIEST WARRIOR PROJECT

Spike TV's "Deadliest Warrior"

Spike TV's Deadliest Warrior was a television series that aired from 2009 to 2011, featuring hypothetical battles between historical warriors from different time periods and regions (Deadliest Warrior, 2009). The show's premise was to simulate the fights between these warriors by using scientific data, computer-generated imagery, and subject matter experts. The show's main host was former Navy SEAL Richard "Mack" Machowicz, who would guide viewers through the simulation process and provide context on the historical significance of the warriors being depicted.

Each episode of Deadliest Warrior focused on two warriors from different periods and regions, such as the Apache vs. Gladiator or Shaolin Monk vs. Maori. The show broke down each warrior's weapons, tactics, and physical abilities and then simulated a hypothetical fight between them using a series of tests and simulations. The show's popularity was largely due to its high production values and the thrilling nature of the simulated battles. While some criticized the show for glorifying violence and oversimplifying complex historical and cultural issues, it remained a popular and entertaining series during its run (Lowry, 2009).

The show's origins can be traced back to a web series created by a software company called Left Field Productions, which featured hypothetical battles between various historical figures. The success of the web series led to Spike TV picking up the concept and turning it into a full-fledged television show. Deadliest Warrior became one of Spike TV's most successful shows, with multiple spin-offs and video games being developed based on its concept.

Assignment Requirements

The project assignment consists of three portions. The first was background research, which comprised 30 of the 100 points assigned to this project. In this section, the students performed background research on two combatants. In particular, they researched their skills and equipment, with a focus on long-range lethality (e.g., bow/arrow, rifles),

short-range lethality (e.g., knives, swords, axes), and survivability (e.g., armor, shields). They assessed each of these dimensions relative to the other combatant.

As part of this step, the student had to assign scores between 0 and 1 for each combatant for the following four metrics: long-range lethality, short-range lethality, long-range survivability, and short-range survivability. A score of 0 indicates that the combatant has an extremely limited capability for a given dimension compared to the other person. For example, a knife-fighter would have a long-range lethality score of 0 if paired up against a trained sniper. On the other hand, a score of 1 indicates that the combatant has unmatched capability in that dimension. The scores for a given metric for the two combatants are required to sum to 1. For example, if Combatant 1 has a long-range lethality score of 0.76, Combatant 2 would have a long-range lethality score of 0.24.

The students had to justify the scores given to each combatant based off their fighting characteristics. For example, a knight in armor would have a much higher long-range and short-range survivability score than an unarmored archer. However, the archer would have a higher long-range lethality score, and they would have comparable short-range lethality scores, assuming that they are both armed with swords. The deliverable from Part 1 was a set of quad charts, with each quadrant addressing one of the four metrics.

An example of a student's quad charts is shown in Figure 2. They compared an Imperial Guardsman from *Warhammer 40k* against a *Star Wars* Imperial Stormtrooper. In each quadrant is a survivability or lethality metric, with an explanation as to how that metric was derived. By requiring students to use this quad chart format, they inherently must justify the scores attached to each metric for each combatant.

The second portion of the project involved building out a stochastic combat model in Microsoft Excel and was worth 50 points. A stochastic model incorporates randomness and uncertainty into its analysis, resulting in varying model outputs with each run. A screenshot of the model is shown in Figure 3. In this Excel sheet, the students generated a set of 4 random numbers between 0 and 1 using a linear congruential generator. The assignment required that students build a linear congruential generator and not use a built-in random number generator. These random numbers were then used to determine who won the conflict using the following rules:

- If the first random number is less than the Lethality – Long Range score for Combatant 1, it means that Combatant 1 dealt a long-range blow to Combatant 2. In that situation, if the second random number is greater than the Survivability – Long Range score for Combatant 2, then Combatant 2 loses; otherwise, there is a draw.
- If the first random number is greater than the Lethality – Long Range score for Combatant 1, it means that Combatant 2 dealt a long-range blow to Combatant 1. In that situation, if the second random number is greater than the Survivability – Long Range score for Combatant 1, then Combatant 1 loses; otherwise, there is a draw.
- If there is a draw, the above process is repeated with the third and fourth random numbers using the Lethality – Short Range and the Survivability – Short Range metrics.

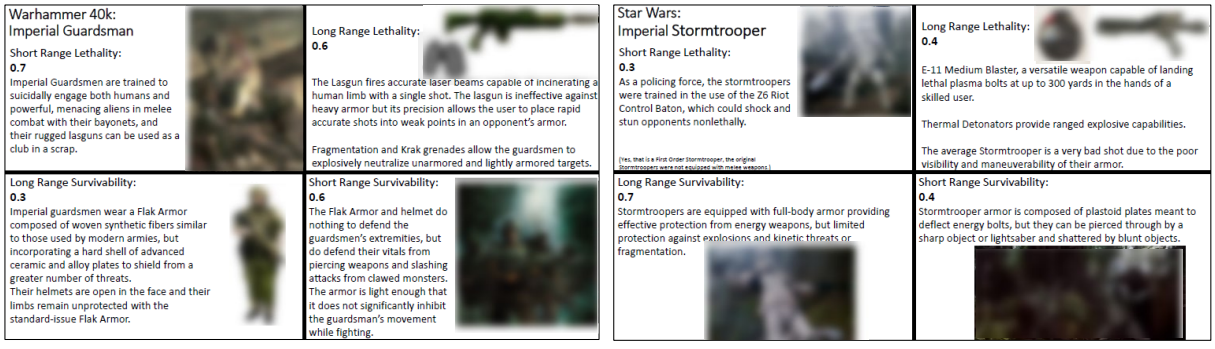
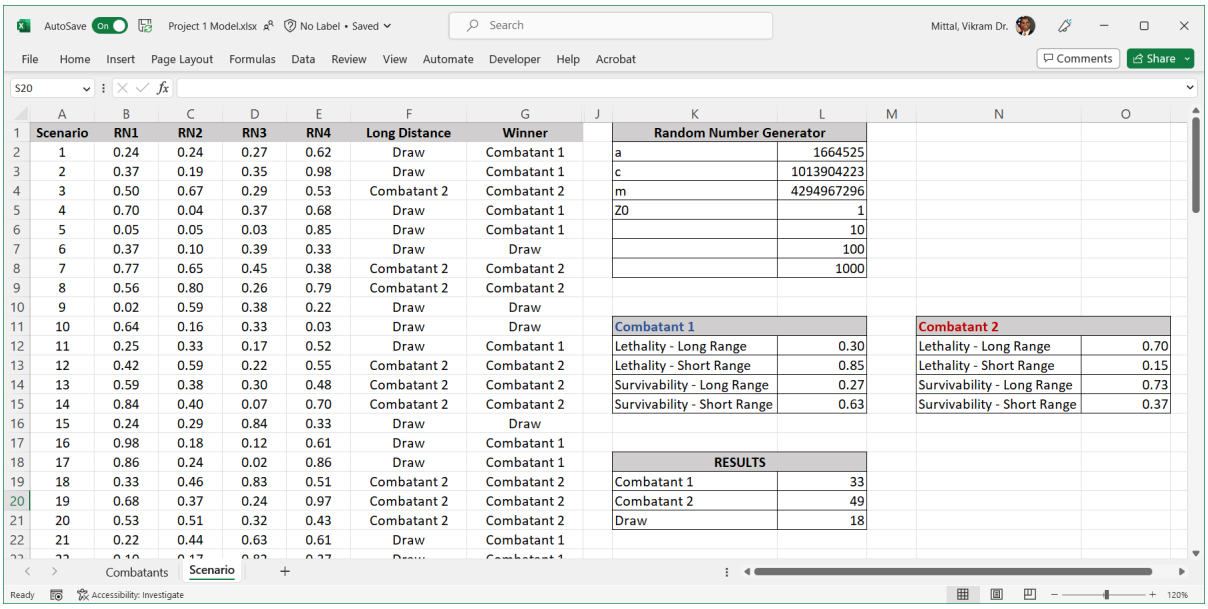


Figure 2. Example of a quad chart deliverable from a student in Fall 2022. Note that images were blurred due to copyright.



Scenario	RN1	RN2	RN3	RN4	Long Distance	Winner
1	0.24	0.24	0.27	0.62	Draw	Combatant 1
2	0.37	0.19	0.35	0.98	Draw	Combatant 1
3	0.50	0.67	0.29	0.53	Combatant 2	Combatant 2
4	0.70	0.04	0.37	0.68	Draw	Combatant 1
5	0.05	0.05	0.03	0.85	Draw	Combatant 1
6	0.37	0.10	0.39	0.33	Draw	Draw
7	0.77	0.65	0.45	0.38	Combatant 2	Combatant 2
8	0.56	0.80	0.26	0.79	Combatant 2	Combatant 2
9	0.02	0.59	0.38	0.22	Draw	Draw
10	0.64	0.16	0.33	0.03	Draw	Draw
11	0.25	0.33	0.17	0.52	Draw	Combatant 1
12	0.42	0.59	0.22	0.55	Combatant 2	Combatant 2
13	0.59	0.38	0.30	0.48	Combatant 2	Combatant 2
14	0.84	0.40	0.07	0.70	Combatant 2	Combatant 2
15	0.24	0.29	0.84	0.33	Draw	Draw
16	0.98	0.18	0.12	0.61	Draw	Combatant 1
17	0.86	0.24	0.02	0.86	Draw	Combatant 1
18	0.33	0.46	0.83	0.51	Combatant 2	Combatant 2
19	0.68	0.37	0.24	0.97	Combatant 2	Combatant 2
20	0.53	0.51	0.32	0.43	Combatant 2	Combatant 2
21	0.22	0.44	0.63	0.61	Draw	Combatant 1

Random Number Generator	
a	1664525
c	1013904223
m	4294967296
Z0	1
	10
	100
	1000

Combatant 1	
Lethality - Long Range	0.30
Lethality - Short Range	0.85
Survivability - Long Range	0.27
Survivability - Short Range	0.63

Combatant 2	
Lethality - Long Range	0.70
Lethality - Short Range	0.15
Survivability - Long Range	0.73
Survivability - Short Range	0.37

RESULTS	
Combatant 1	33
Combatant 2	49
Draw	18

Figure 3. Structure of SE485: Combat Modeling, including the projects tied to each major block of instruction.

The above logic could all be built into one row in the spreadsheet. As such, by copying the row down 100 times, and seeding subsequent random numbers from the previous random number, the model can be replicated 100 times. The model then outputs the percentage of runs that each combatant wins and the percentage of runs ending in a draw.

The final portion of the project involved an in-class presentation worth 20 points. The guidelines for the presentations were as follows:

- 5 slides including title slide (do not include a slide for questions or references),
- Each slide can have a maximum of 3 pictures and 20 words,
- The slide deck should be set to automatically flip each slide at exactly 30 seconds, and
- The presentation cannot be more than 2MB.

An example of another student's final presentation is shown in Figure 4. Their combat pitted Erik the Red against Attila the Hun. The presentation was limited on the number of figures and words that could be on each slide, so students had to determine the essential information that they wanted to present on each slide.

Project Goals

While the other course projects align with the major blocks of the course, this project is intended to serve as an introduction to combat modeling. It does apply certain concepts, including random number generation; however, the overall intent is to introduce students to combat models, while allowing students to have fun, such that students have some "buy-in" on the course. If students get excited about the course material, they are generally more receptive to learning the material (Macal, 2013).

Figure 4. Example of final project deliverable from a student in Fall 2022.

Since the students must build the model from scratch, it reinforces general engineering design practices. Students must initially perform background research, looking up information on the two combatants. They must then analyze the results of their background research to assign them survivability and lethality metrics, tying these metrics back to their background research. The students must then logically lay out their model. While they are given requirements on how to build the model, they have to develop their model framework to meet these requirements. Students then must logically write out the code, using a series of nested if statements. This skillset of designing and building a model based on background research and simple logic is a useful skillset for any model developer (Bernier, 2016).

The other goal of this project is to teach students that combat models do not necessarily have to be agent-based simulations such as IWARS. Indeed, mathematical models are especially useful for performing a range of analyses and often provide more flexibility than agent-based simulations (Kaiser, 2017). Rather, a combat model can consist of a thorough analysis coupled with a simple mathematical model that compares two combatants.

Model

The model for this project is developed in Microsoft Excel. An example of the Excel spreadsheet is shown in Figure 3. The first column is the scenario number. Columns 2-5 are a series of random numbers. For this assignment, students had to use a linear congruential generator based off four random number seeds to create each sequence of random numbers. The equation for the nth random number (RN) in a sequence is:

$$RN_n = MOD(a \times RN_{n-1} \times m + c, m) \div m$$

Where a, c, and m are constants. For this project, students use values from ANSI C for these parameters. Students also have to feed each sequence of random number sequence with a seed (RN_0).

The model generally consisted of seven columns of Excel code. The code is given in Table 1 and uses the following variables:

- L_LR1, L_LR2: Lethality at long range for combatant 1 and combatant 2 (L_LR2 = 1 – L_LR1)
- L_SR1, L_SR2: Lethality at short range for combatant 1 and combatant 2 (L_SR2 = 1 – L_SR1)
- S_LR1, S_LR2: Survivability at long range for combatant 1 and combatant 2 (S_LR2 = 1 – S_LR1)
- S_SR1, S_SR2: Survivability at short range for combatant 1 and combatant 2 (S_SR2 = 1 – S_SR1)
- A_RN, C_RN, M_RN: constants in a linear congruential generator

The first column indicates the scenario number, spanning from 1 to 100. The next four columns are sequences of 100 random numbers, with four random numbers being used per scenario. The sixth column uses the first two random numbers with the long-range survivability and lethality metrics to determine the outcome of the long-range fight, which can end in either combatant winning or a draw. The seventh column then determines who would win in a short-range engagement based off the short-range metrics, given that the long-range fight ends in a draw. The outputs from

Table 1. Excel Code given for each Row 3 of the model shown in Figure 3.

Column	Description	Excel Code for Row 3
A	Scenario #	A2+1
B	Random Number 1	=MOD(A_RN * (B2 * M_RN) + C_RN, M_RN) / M_RN
C	Random Number 2	=MOD(A_RN * (C2 * M_RN) + C_RN, M_RN) / M_RN
D	Random Number 3	=MOD(A_RN * (D2 * M_RN) + C_RN, M_RN) / M_RN
E	Random Number 4	=MOD(A_RN * (E2 * M_RN) + C_RN, M_RN) / M_RN
F	Winner of Long Range	=IF(B3 < L_LR1, IF(C3 < S_LR2, "Draw", "Combatant 1"), IF(C3 < S_LR1, "Draw", "Combatant 2"))
G	Overall Winner	=IF(F2 = "Draw", IF(D3 < L_SR1, IF(E3 < S_SR2, "Draw", "Combatant 1"), IF(E3 < S_SR1, "Draw", "Combatant 2")), F3)

the final column are then aggregated to determine the percentage of fights where each combatant wins along with the number of draws.

OBSERVATIONS

Student Projects

This project was administered to students during the fall semesters during 2019, 2020, 2021, and 2022. Each semester, there are between 30 and 50 students enrolled in the course. A compilation of combatants is shown in Figure 5. As can be noted from the list, the students were given the ability to pick any project topic that they desired. They can broadly be broken down into the following categories:

- Ancient history (pre-guns): Spartan Hoplite vs Roman Legionnaire
- Recent history: Waffen-SS (German) vs 101st Airborne (US) infantry soldiers during World War II
- Contemporary: Donald Trump vs Vladmir Putin
- Comic Books: Superman vs Deadpool
- Anime: Edward Elric (Fullmetal Alchemist) vs. Naruto Uzumaki (Naruto)
- Movies and Television: John Wick vs Jason Bourne
- Video game characters: Marcus Fenix (Gears of War) vs John-117 Master Chief (Halo)
- Sports: Michael Jordon vs Lebron James
- Hybrid: Gandolf the Wizard vs Santa Claus

It is worth noting that a number of students chose unique combatants, rather than simply relying on the standard combatants (e.g., Batman vs Superman). As obvious from Figure 5, students were creative in their selection of combatants.

Common Issues

The most common issue with the projects was the quality of the assessment of each combatant's lethality and survivability metrics. In the first year of the project, less guidance was given to students for assigning these scores. As such, students ended up feeling that they were simply "making up numbers" rather than assessing each combatant's relative lethality and survivability. To remedy this issue, the assignment was modified to require students to submit quad chart with background research justifying these assessment scores. Points were subsequently deducted for poor justifications or illogical lethality and survivability scores. For example, in Academic Year 2020, a student assigned a higher short-range lethality score to Ben Franklin than George Washington because the *pen is mightier than the sword.* While a common saying, clearly a person with a sword would be more lethal in a fight than someone with a pen.

Batman vs. Spiderman	Luke Skywalker vs. Neo	Deadpool vs. Harley Quinn
Darth Vader vs. Voldemort	The Terminator vs. Robocop	Captain Marvel vs. Supergirl
Captain America vs. Thor	Ben Franklin vs. George Washington	Wolverine vs. Sabretooth
Iron Man vs. Superman	Army Football vs. Navy Football	Black Panther vs. Blade
John Wick vs. Jason Bourne	Katniss Everdeen vs. Legolas	My Dad vs. Jerry's Dad
Wonder Woman vs. Black Widow	King Kong vs. Godzilla	Superman vs. Captain Atom
Sherlock Holmes vs. James Bond	Sherlock Holmes vs. Hercule Poirot	Thor vs. Doctor Manhattan
John Wick vs. Rambo	Buffy the Vampire Slayer vs. Blade	Harry Potter vs. Hermione Granger
Wolverine vs. Deadpool	Dracula vs. Frankenstein's Monster	Batman vs. Captain Cold
Goku vs. Naruto	The Bride (Kill Bill) vs. John Rambo	Genghis Khan vs. Julius Caesar
Harry Potter vs. Percy Jackson	Waffen-SS vs. 101st Airborne (WWII)	Spiderman vs. Venom
Hannibal Lecter vs. Dexter Morgan	Rocky Balboa vs. Muhammad Ali	Wonder Woman vs. She-Hulk
The Joker vs. Magneto	Naruto Uzumaki vs. Ichigo Kurosaki	James Bond vs. Jason Bourne
Indiana Jones vs. Lara Croft	The Flash vs. Quicksilver	Superman vs. Deadpool
Jason Bourne vs. Ethan Hunt	Dr. Strange vs. Doctor Who	Neo vs. Morpheus
William Wallace vs. Maximus	The Punisher vs. Daredevil	The Joker vs. The Riddler
Genghis Khan vs. Alexander the Great	Edward Elric vs. Naruto Uzumaki	Thor vs. Loki
Julius Caesar vs. Napoleon Bonaparte	The Mandalorian vs. Boba Fett	Iron Man vs. Doctor Doom
Joan of Arc vs. Mulan	Arya Stark vs. Jon Snow	Sherlock Holmes vs. Monk
Robin Hood vs. Zorro	Jason Voorhees vs. Michael Myers	Achilles vs. Hector
Jack Sparrow vs. Captain Hook	Erik the Red vs. Attila the Hun	Kenshiro vs. Jotaro Kujo
Gandolf vs. Santa Claus	Sherlock Holmes vs. Miss Marple	Spartacus vs. Maximus
Gandalf vs. Dumbledore	Indiana Jones vs. Nathan Drake	Marcus Fenix vs. Master Chief
Hoplite vs. Legionnaire	Batman vs. Daredevil	Hannibal vs. Scipio Africanus
Jean Grey vs. Professor X	Michael Jordan vs. Lebron James	Sun Tzu vs. Miyamoto Musashi
Storm vs. Black Lightning	Monkey D. Luffy vs. Goku	Hawkeye vs. Green Arrow
Green Lantern vs. Nova	Robin Hood vs. William Tell	Blade vs. Morbius
Magneto vs. Apocalypse	Donald Trump vs. Vladmir Putin	Frozone vs Dr. Doofenschmirtz
Superman vs. Batman	Saitama vs. All Might	Doctor Strange vs. Scarlet Witch
John Snow vs. Legolas	Captain America vs. Black Panther	Wolverine vs. Omega Red
Black Panther vs. Wonder Woman	Imperial Guardman vs. Imperial Stortrooper	Wonder Woman vs. Captain Marvel

Figure 5. List of combatants selected by students in SE485

The second common issue that arose was that students overly-trusted their model and did not perform a sanity check to make sure that their model was set up correctly. For example, in Academic Year 2019, a student had one of their combatants always lose, even though they clearly had better lethality and survivability metrics than their opponent. However, the student insisted that their own instincts were wrong and that the results must be right since "that is what the model said." This served as a useful lesson on the need to verify and validate models rather than simply trusting their outputs.

ASSESSMENT

Grades

Figure 6 displays the grades breakdowns for the three portions of the project. Overall, the average grade on the assignment was 92.8 points, with most students getting an overall A on the project. Approximately 6 percent of students earned a perfect score on this project.

The first part of the project was the quad chart, where students earned an average of 27.5 out of 30 points. Approximately 45 percent of students got perfect scores, with 13 percent having minor formatting issues. A quarter of students had faulty logic in their analysis. For example, one student claimed that at short distances, "the pen is mightier than the sword;" while a common saying, a sword is indeed better for close quarters combat than a pen. A non-trivial number of students missed the requirement for the quad chart or thought that it was simply part of the presentations; hence they did not submit this portion of the assignment on time, accruing a hefty late penalty.

The second part of the project was the Excel-based model. On this portion, students earned 46.8 out of 50 points. Approximately a third of the students had a perfect submission. Another third only had very minor mistakes. These were typically incorrect cell references or a flipped inequality. The final third of the project had larger issues. Some of these range from incorrect logical flow. Other students lost considerable points for using the built-in random number generator instead of building a linear congruential generator.

Students earned an average of 18.5 out of 20 points on the project presentation, the third part of the project. Approximately a quarter of students gave good presentations that met all of the requirements, which were fairly stringent for the presentation. In particular, the slides were required to automatically change at 30 second intervals. Approximately 35 percent of students had slight delivery issues, mainly awkward pauses while waiting for slides to change. The remainder of the students gave presentations that either missed important components or did not follow the set requirements.

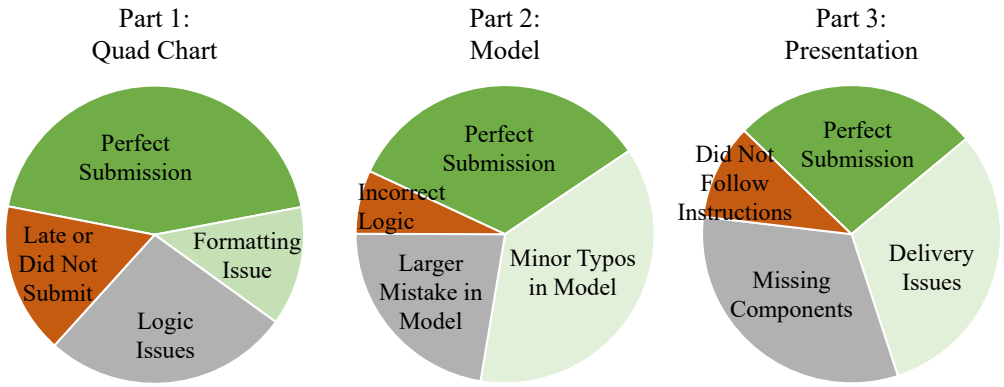


Figure 6. Breakdown of issues associated with deliverables for each portion of the "Deadliest Warrior" project.

Students generally scored well on this project. This was in part because students tended to score poorly on the later projects in the course; as such, this project was in part intended as a grade boost. However, students generally embraced this project more than other projects, putting more effort into developing a quality product.

Course End Feedback

This project aligns with the following three course objectives:

- Build a random number generator and use it to generate random variates from select probability distributions.
- Create models by analyzing data collected through test experimentation.
- Conduct meaningful analysis and present the results of simulated models.

These objectives are tracked after the end of each semester through surveys given to the students, where they indicated how well they felt that the course performed in meeting a given objective. The questions are on a four-point scale, where a score of one indicates that the course did a poor job covering the objective. Meanwhile a score of four indicates that the course did an excellent job covering the objective. The student scores are shown for three relevant course objectives in Figure 7 from 2015 to 2022.

There is an increase in the scores for all three objectives in 2018 with the introduction of the project. In particular, there was no project connected to random number generation, and students were only assessed on the topic in an examination. The inclusion of random number generation in a course project substantially increased the level of understanding the students had with the associated course objective. The other two lesson objectives were already somewhat addressed by other projects. Regardless, the inclusion of this project coincides with an increase in the students' assessments of how well the course taught these course objectives.

Student Feedback

Following each assignment, students are asked about their thoughts and feedback to allow for incremental improvements on the projects. Most of the feedback for this project has been positive. Below are selected excerpts from their positive feedback:

- "This project was fun!" - Multiple students from every year.
- "The Deadliest Warrior is my favorite show! I had so much fun pitting a Spartan soldier against a Viking." - Student from Academic Year 2021
- "I always wanted to learn how to do something like this!" - Student from Academic Year 2022
- "I didn't realize you could to that with Excel!" – Student from Academic Year 2022
- "At first, I thought this exercise was just an exercise in random number generation. However, I learned a lot more in how to make estimates and assumptions for a model." - Student from Academic Year 2021

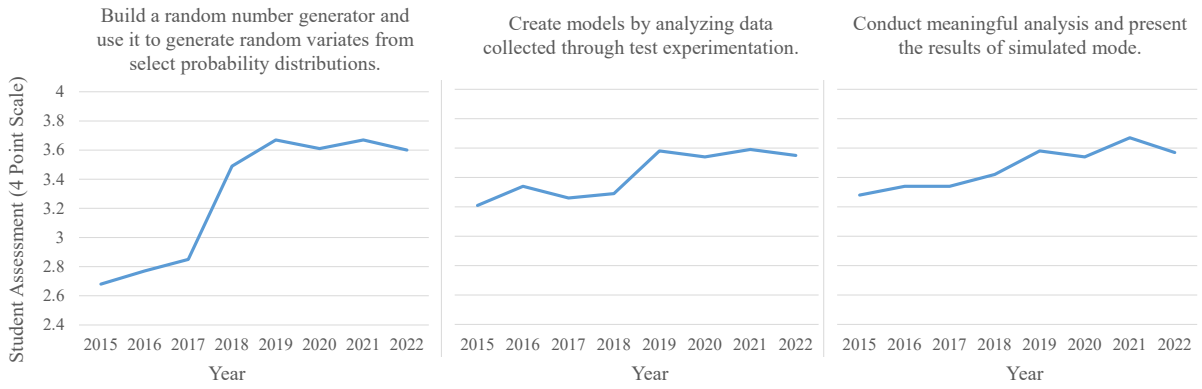


Figure 7. Student responses in course-end feedback for course objectives related to the "Deadliest Warrior" project. Note that the project was started in 2018.

Despite the generally positive feedback, a few students provided feedback that was more critical:

- "I do not understand why we need to build our own random number generator for this project. It provides no value and the LCG is not as good as the built-in Excel tool." - Student from Academic Year 2020
- "I did not like the presentation. It was hard to get the timings right." - Student from Academic Year 2021
- "I felt that we were making up numbers for survivability and lethality." – Student from Academic Year 2022

Generally, the more critical feedback was fairly limited with the main criticism being tied to learning objectives for the project. The presentation portion of the project is not popular with students since the automatic slide transitions force the students to rehearse it multiple times, as opposed to presentations in other classes that are commonly not rehearsed.

PROJECT EXTENSION

In the following block of the course, students learn about the Lanchester Equations, which are a series of paired differential equations that models attrition of large forces in combat. In particular, if a red and a blue force are engaged in combat, then the equations generally have the form of:

$$\frac{dB}{dt} = -\beta_R R \text{ and } \frac{dR}{dt} = -\beta_B B$$

where B and R are the number of blue and red forces at a given time, and β_B and β_R are attrition coefficients.

One common challenge with the Lanchester Equations is determining the attrition coefficients used in these equations. Typically, these coefficients are estimated based on historical data or equipment performance data. In this exercise, one approach to approximating these coefficients is through the use of simple combat models. Let's consider a scenario where a blue army is engaged in combat with a red army. To approximate the attrition coefficients for the Lanchester equation model associated with this scenario, the process outlined in this paper can be followed. Firstly, the modeler needs to conduct a thorough analysis and establish metrics for survivability and lethality. These metrics will serve as indicators of the soldiers' ability to survive and cause damage. The model employed developed in this paper provides

the probability of a red soldier killing a blue soldier and vice versa during a given time step. These probabilities, obtained from the model, can be used as approximations for the attrition coefficients.

Moreover, much of the later portions of the course are tied to using IWARS, an agent-based model for small-unit military operations. One common issue is that the model results are only applicable to the mission scenario that was modeled. The students learn that they can use the outcomes of their models to frame the survivability and lethality metrics that serve as the inputs to the "Deadliest Warrior" model to determine the overall probability of success. In doing so, they can scale up the analysis from a small unit operation to a much larger military operation.

CONCLUSIONS

It is perfectly natural for a person to wonder who would win in a fight between two different individuals. Indeed, the author's children spend ample time watching YouTube videos dedicated to who would win in a fight between different dinosaurs. This paper sets out to capture this general interest to introduce students to combat modeling through a project where they build a model inspired by Spike TV's "Deadliest Warrior." The project required students to research two fighters and build out a stochastic model in Microsoft Excel that would capture the winner in 100 duels between the two fighters. In doing so, the students also learn how to develop a simple Excel-based model based on sound logical reasoning that does not require the use of a complex simulation package.

Overall, the students embraced the project, selecting a range of different fighters. While some students went with mundane Superman vs. Batman fights, many went with more creative engagements. The general purpose of this project was to get students excited about combat modeling and it appears to have served that purpose. Moreover, it taught students how to build random number generators and stochastic mathematical models. The grades for the assignment indicate that most students took the assignment seriously and put in the required amount of effort. Additionally, the course assessments found that students felt that from the project they had a better understanding related to specific course objectives.

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