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# Avoiding Pitfalls in Undergraduate Simulation Courses

Vikram Mittal
*United States Military Academy*, vikram.mittal@westpoint.edu

Eugene Lesinski
*United States Military Academy*

Matthew Dabkowski
*United States Military Academy*

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**Vikram Mittal, Gene Lesinski, Matthew Dabkowski**
**Department of Systems Engineering, United States Military Academy**
**West Point, NY**
**vikram.mittal@westpoint.edu, eugene.lesinski@westpoint.edu, matthew.dabkowski@westpoint.edu**

## ABSTRACT

Simulation development has historically been a specialized skill performed by engineers with graduate-level training and industry experience. However, advances in computing technology, coupled with the rise of model-based systems engineering, have dramatically increased the usage of simulations, such that most engineers now require a working knowledge of modeling and simulation (M&S). As such, an increasing number of undergraduate engineering programs are now requiring students to complete a simulation course. These courses are intended to reinforce foundational engineering knowledge while also teaching the students useful M&S tools that they will need in industry. Yet, a number of pitfalls are associated with teaching M&S to undergraduate students. The first major pitfall is focusing on the tool or software without properly teaching the underlying methodologies. This pitfall can result in students becoming fixated on the software, limiting their broader knowledge of M&S. The second pitfall involves the use of contrived, academic tutorials as course projects, which limits students from fully understanding the simulation design process. The third and fourth pitfalls are only superficially covering verification and validation and not building upon material that was taught in other courses. Finally, the fifth pitfall is the over-reliance on group projects and tests over individual projects. These pitfalls were uncovered during academic years (AYs) 2017 and 2018 in different undergraduate simulation courses at the United States Military Academy. The combat modeling course adapted its structure and content in AY2019 to address these pitfalls, with several lessons learned that are applicable to the broader simulation education community. Generally, students gained a broader understanding of M&S and submitted higher quality work. Additionally, the course-end feedback found an overall increase in M&S knowledge, with many students choosing to use M&S to support their honors theses and capstone projects, a trend not seen in past years.

## ABOUT THE AUTHORS

**Dr. Vikram Mittal** is an Assistant Professor in the United States Military Academy's (USMA) Department of Systems Engineering. He holds a BS in Aeronautics from Caltech, a MSc in Aerospace Engineering from Oxford University, and a PhD in Mechanical Engineering from MIT. Prior to teaching at USMA, he was a senior mechanical engineer at Draper Laboratory. Dr. Mittal's research interests focus on M&S, model-based systems engineering, robotics, and energy. In his teaching capacity, he is the course director for the Combat Modeling course at USMA.

**Mr. Gene Lesinski** is an Assistant Professor in USMA's Department of Systems Engineering. He retired from the Army after 23 years with a background in the Infantry and Operations Research / Systems Analysis. He is a graduate of USMA's Class of 1985 with a degree in Civil Engineering. He holds an MS in Systems Engineering from UVA. Mr. Lesinski's research interests focus on computational intelligence, system design, and system architecture.

**COL Matthew Dabkowski** is the Program Director for USMA's Systems Engineering Program. He is a career Army officer with a background in Infantry and Operations Research / Systems Analysis. He is a graduate of USMA's Class of 1997 with a degree in Operations Research. He holds an MS in Systems Engineering and a PhD in Systems and Industrial Engineering from the University of Arizona. COL Dabkowski's research interests focus on network science, decision analysis, and applied statistics.

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## INTRODUCTION

Modeling and simulation (M&S) courses are a key component of any engineering curriculum. The role of these courses has become more prominent over the past decade following advances in computing technology, coupled with the rise of model-based systems engineering (Wasserman, 2018). The goal of M&S courses is to reinforce foundational engineering knowledge while also teaching the students the M&S tools that are used in industry (Stern et. al., 2006). However, with the increased demand by industry for engineers that are proficient in certain simulation packages, these courses have become more focused on teaching the tools, introducing a number of pitfalls. The first major pitfall stems from the increased focus on the simulation software and reduced focus on teaching the underlying methodologies. Since the instruction is heavily tied to a software package, a second pitfall arises from the over-use of the software tutorials, resulting in students learning how to operate the software versus how to design the simulation. The third pitfall and fourth pitfalls are superficially covering verification and validation and not building on material taught in prerequisite and complementary classes. Finally, the fifth pitfall is the over-reliance on group projects and tests over individual projects.

These pitfalls were identified in a combat modeling course at the United States Military Academy (USMA) leading up to Academic Year (AY) 2018. On further analysis, it was uncovered that these pitfalls were common in other simulation courses both internal and external to USMA. In AY2018 and AY2019, the combat modeling course adopted numerous changes to counter these pitfalls, with several lessons learned that are applicable to the broader simulation education community. These changes resulted in students gaining a better understanding of M&S and applying their simulation skills to their senior design projects.

## EVOLUTION OF COLLEGE SIMULATION COURSES

A sharp distinction can be drawn between undergraduate and graduate engineering degrees. Undergraduate engineering degrees cover the underlying foundational knowledge of the discipline, allowing students to develop a broad base of information which they can apply in graduate school or in industry (ABET, 2019). Meanwhile, graduate programs include classes that are narrower, focusing on specific processes and tools that the student will need for their graduate research. Typically, M&S courses have been taught at a graduate level and tailored to the school, its research threads, and the prevailing simulation packages for that research area (Hlupic, 2000, Magana, 2017). As such, industry relied on engineers with graduate-level training for building its simulations.

Since the late 1990s, there has been a significant increase in the usage of M&S by the engineering industry (Sokolowski & Banks, 2010). This increase is partially due to advances in computing technology coupled with the availability of user-friendly simulation platforms. Additionally, the engineering industry is developing and analyzing increasingly complex systems that require simulations to understand component interactions, properly forecast system performance, and inform design decisions. As such, junior engineers without postgraduate degrees are now required to have M&S skills (Hlupic, 2000).

Since industry needs engineers with M&S skills, the role of undergraduate M&S courses has changed. Originally, the goal of undergraduate simulation courses was to introduce students to M&S, such that they would have an appreciation of the role that it plays in the larger engineering design process. Students would learn some of the underlying methodologies and then work through problems that simulations would help to address. By the end of the course, students would have a good foundation of fundamental M&S knowledge; however, further classes, either in graduate school or in industry, would be necessary for them to actually implement M&S in practice. However, over time,

undergraduate simulation courses became much more software-focused, encouraging students to learn how to operate a specific piece of software. The simulation software is somewhat domain specific and can range from complex, commercial packages such as Simul8, Arena, and ProModel, to more fundamental, academic packages built in Matlab or R. While there are numerous benefits to this approach, mainly that the graduates of that program know a specific tool that will make them attractive to industry, it has several challenges that must be overcome to ensure that students learn the requisite skill sets for simulation design.

**OVERVIEW OF SYSTEMS ENGINEERING 485 COURSE**

*Systems Engineering 485 (SE485) – Combat Modeling* is an M&S course at USMA that introduces students to the theoretical and practical issues in combat modeling and simulation. It covers a range of fundamental M&S topics to include: the role of random numbers; probabilistic underpinnings of simulation; verification, validation, and accreditation; methods of designing and conducting simulation experiments; modeling techniques; and analysis of results. The students learn and apply algorithms specific to combat M&S, such as target detection, shot delivery accuracy, and casualty assessment.

When the course was first developed in the early 1990s, the underlying software used for the class was JANUS, a tactical combined arms simulation (TRADOC Analysis Center, 2006). Subsequently, the software was changed to One Semi-Autonomous Force (One-SAF) and then to the Infantry Warrior Simulation (IWARS) (Wittman, 2001, Borgman, 2007). IWARS is an entity-based, multi-sided simulation program that focuses on small-unit Army accredited operations. The underlying methodologies are powered by a detailed database that captures the associated parameters. IWARS was found to have an intuitive user-interface, such that after 10 to 15 hours of lab exercises students became proficient using it.

Similar to other M&S courses, SE485 quickly became known as the "IWARS class" because students felt that the only objective of the course was to learn the software. Since IWARS' introduction into SE485 in AY2010, the course had implemented a three-part structure. In the first third of the class, students were introduced to IWARS through a series of tutorials that accompanied the software. In the second third of the class, the students learned the methodologies that drive IWARS, such as target acquisition, shooting accuracy, and incapacitation. During the final third of the class, the students learned some of the advanced features of IWARS and applied them to a culminating project.

The authors of this paper were assigned as SE485 instructors for AY2018 and AY2019, and they identified several issues with this structure. To better understand these issues and current teaching practices, the authors analyzed a broad range of undergraduate simulation courses; in particular, they looked at simulation courses at USMA in the systems engineering department, as well as those in the mechanical engineering and electrical engineering departments. They also reviewed the syllabi and assignments of different simulation courses at peer institutions including Columbia University, Georgia Institute of Technology, New York University, Northwestern University, Purdue University, Texas A&M University, University of Arizona, and University of Virginia. They found that most courses follow a similar structure to SE485 and would likely face similar pitfalls.

Though none of these pitfalls are severe enough to fully derail a course, avoiding these pitfalls will increase the efficacy of the course. The following sections share some of the measures that were implemented for SE485 to avoid these pitfalls, as well as an assessment as to the overall effects of these measures. Overall, by avoiding the pitfalls, they found that the course improved the students' knowledge of M&S and their ability to apply the course material to real-world problems. Similar measures can be applied to many of the simulation courses that were reviewed, helping to bolster their programs.

**PITFALLS**

**Pitfall 1: Not Building the Underlying Methodologies for the Simulation**

Many simulation classes have simply become a class that teaches a software package, glossing over the underlying methodologies. These methodologies are critical for understanding the simulation software. For example, the methodologies for a combat modeling class would include how to model a soldier shooting, moving, and communicating, as well as more basic algorithms such as random number generation. A thorough understanding of

the methodologies reinforces foundational knowledge from other courses while also teaching the students how the underlying mechanisms drive the simulations (Ribeiro et. al., 2018). In turn, this knowledge allows students to understand the limitations of the simulation software, as well as how to adapt the methodologies for specific cases.

Though the review of different programs did identify that most simulation courses teach methodologies, projects and homework assignments seldom required students to actually build these methodologies into a model. Alternatively, methodologies were typically included in quizzes and exams, which normally required students to work out math problems to show that they understand how to generate outputs from inputs but lack understanding of fundamental methodology. This test-based approach also facilitated efficient assessment, as the math problems tended to be easier for instructors to evaluate.

Not only does this situation create a disconnect between the course material and exams, but it also allows students to compartmentalize the methodologies from the actual simulations. As a consequence, students do not fully appreciate how the methodologies actually drive the simulation. Moreover, after the conclusion of the course, they simply have learned a software package without understanding its underlying processes, thereby reducing their ability to modify the underlying methodologies or learn similar software packages in the future.

SE485 identified this disconnect during AY2017 when students complained about differences between the exams and the course material; the underlying analysis identified this issue as the root cause. In order to address this issue, SE485 delayed the introduction of IWARS to the students by five lessons and required them to learn how to build stochastic combat models for basic target acquisition and shooting methodologies in Microsoft Excel. A course project complemented this approach, where students collected marksmanship data to look at changes in shot group accuracy based on a soldier's physical fitness and weapons proficiency. Finally, the students built a stochastic model in Excel, where two soldiers were shooting at each other from a known distance with different levels of physical fitness and weapons proficiency. Upon learning IWARS, they would replicate this spreadsheet model in the simulation software and identify changes.

**Pitfall 2: Over-use of Software Tutorials**

Many M&S courses follow a set course structure built around teaching the simulation software package. These courses utilize a series of structured tutorials of increasing difficulty to teach the software package (Macal and North, 2010). As shown in Table 1, these tutorials are divided into three stages - introductory, intermediate, and advanced. The first stage focuses on familiarizing students with the software, such that they understand its capabilities, inputs, and outputs. The second stage allows students to learn the features of the software, such that they understand how to build simulations to get the desired outputs. The third stage is much more open-ended, where students can get a taste of the full power of the simulation package. As students progress through these tutorials, there is less "hand-holding" such that students develop a better understanding of how to use the software, as opposed to just following a sequence of steps. This approach is based on a number of different studies that have identified this technique as an effective way to teach software (Cohen, 2002).

Course assignments–including in-class problems, homework assignments, projects, and exam–often align with these tutorial exercises, which are typically pulled directly from the software tutorial packages or accompanying textbooks with little to no modification. When they are modified, they are parallel applications that mimic the tutorial. Since these tutorials are not specific to the course, they are overly abstract so that they can apply to a diverse set of courses. Additionally, these tutorials only undergo minor updates, such that they may lack relevancy to modern issues. As a consequence, students simply learn how to feed the computer an input, "turn-the-knob," and get an output for a fixed set of cases. Naturally, students develop a reduced respect for M&S and simply treat it as a tool for justifying a decision, rather than a powerful mechanism for exploring a tradespace.

Historically, SE485 used the standard tutorials provided by the developers of IWARS to not only teach the software but also as the course homework assignments and projects. Though the IWARS developers had put significant effort into the development of these tutorials, they were overly generic and somewhat contrived. Students would learn the basics of IWARS, but they did not develop an understanding of the role that M&S plays in the engineering design process. As such, the course curriculum was modified, especially regarding the course projects. Instead of using the tutorials, the course had students use IWARS to analyze and explore solutions for modern Army challenges. These projects were intentionally left open-ended, giving students the freedom to fully explore the tradespace. This freedom allowed students to better understand the strengths and limitations of M&S by allowing them to frame their own solutions relative to these problems.

**Table 1: Stages of tutorial exercises used in simulation courses**

| Stage | Goal | Characteristics of Tutorial | Example from SE485 |
|---|---|---|---|
| Introductory | Familiarization with software | Short and well-defined | Two stationary soldiers engaging each other |
| Intermediate | Learn features of software | Short and slightly generalized | Four mobile soldiers engaging stationary targets |
| Advanced | Explore capabilities of software for analysis | Long and vague | Ten soldiers in vehicles engaging moving targets |

**Pitfall 3: Inadequate Coverage of Verification and Validation**

Verification and validation (V&V) are two critical steps for simulation development. In particular, the simulation's outputs are a function of the simulation's inputs and modeling parameters; more simply put, garbage in results in garbage out (Tolk, 2012). As such, students need to be able to question their results, understand the dependencies of the outputs to the model assumptions, and ensure that their results make sense.

From the review of simulation courses, almost every course included at least one lesson on V&V. These lessons typically covered the importance of V&V and addressed them as a critical step in the simulation process. However, the classes did not cover the actual processes that are associated with V&V, nor did they give any practical problems. Furthermore, V&V were only tangentially covered in homework assignments, projects, or exams. As a consequence, students can potentially take the output of a model at face value, even if the results do not make sense.

An example of this failing can be readily seen in a previous course project for SE485. In this project, friendly forces engaged enemy forces, some of whom were in a sitting position. Due to an incomplete database in IWARS, soldiers in a sitting position are invulnerable, such that they can be shot many times and not die. Over the course of 3 years, no students questioned the fact that certain enemy soldiers were not dying, even though the model was clearly showing that these seated enemy soldiers were getting shot. When this issue was noticed in AY2018, it presented an excellent opportunity for a V&V exam problem. In this exam problem, students were asked to build a simple model where two friendly forces walk into a room and shoot 200 rounds at two enemy soldiers that were sitting down at a distance of 10 meters, as shown in Figure 1. The enemy forces did not engage the friendly forces. Students were then asked about what was wrong with the scenario. In AY2018, only 2 students out of 35 correctly identified the issue, with the most common incorrect response being soldiers should not shoot un-armed enemies that are sitting down. During AY2019, the V&V lesson became somewhat more extensive, including having students identify common issues in IWARS. When a similar question was subsequently asked on an exam in AY2019, approximately 75 percent of students were able to correctly identify the issue.
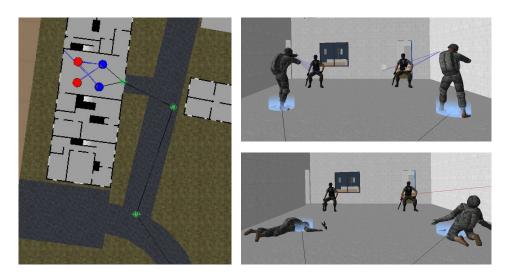
**Figure 1: IWARS model used to assess students' ability to verify that a model is running correctly. Blue forces enter a room and fire 200 rounds into two sitting red forces (left and top right). The *armed* red forces do not die and eventually return fire with 2 rounds, killing the blue forces (bottom right).**

**Pitfall 4: Making the Simulation Course a Stand-alone Course**

The structure for engineer curricula, as shown in Figure 2, has simulation courses as a methodology course that builds upon foundational engineering knowledge and provides students the tools necessary to succeed in their capstone, thesis, or design courses (ABET, 2019). However, M&S courses are often treated as a stand-alone course (Macal and North, 2010). As such, the students learn about simulation but do not fully appreciate how simulation feeds into the overall engineer design process. Moreover, they lose the opportunity to apply simulation to solve issues outside of their simulation course.

Simulation courses typically do not adequately build on the course material covered in prerequisite courses. To the contrary, they often fully cover relevant course material from the prerequisites, as opposed to simply providing a review, such that students are "relearning" prerequisite material rather than applying this material to simulation. This issue naturally arises from a misalignment between foundational classes and the simulation course.
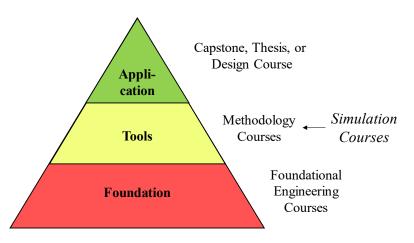


**Figure 2: Standard structure for current engineering curricula**

Similarly, the simulation course is often not adequately tied into the culminating experience of undergraduate engineering programs—the capstone, thesis, or design course—where students use all the knowledge and tools that they have learned to solve a real problem. These courses provide students a large amount of freedom to develop the problem-solving methodology for their project. However, unless the project is directly related to simulation, with the advisor or customer directly requesting the students to build certain simulations, students typically avoid developing comprehensive simulations to better understand their problem or to evaluate design decisions. This issue also stems from the somewhat disjointed nature of many engineering curricula, where students see the M&S course has a stand-alone course, rather than a methodology course. A second cause could stem from the over-use of tutorials where students are not able to teach themselves how to mold the software for their individual needs.

SE485 attempted to address this issue by aligning the course better with its prerequisites. A review of the syllabus found that six out of forty class periods were dedicated to statistical analysis and design of experiments, two items covered in the prerequisites. Both SE485 and the prerequisite changed how this material was covered to have better alignment. In doing so, the six class periods could be reduced to two in AY2018, providing more time for methodologies and applications of simulation.

Additionally, the final course project for SE485 was changed to be more in-line with an open-ended research problem, similar to what students would be doing as part of their capstone experience. For example, in AY2018 students developed models and analyzed how to counter grenades being dropped from commercial drones, a tactic that insurgent groups had recently adopted that was posing a threat to the Army. Similarly, in AY2019 the course project required students to model cyber-attacks on a tactical unit. These real-world projects gave students the experience and confidence needed to apply simulations for their capstone projects, theses, or as part of design courses. Prior to AY2018, the final course projects had been much more structured with closed-form solutions.

**Pitfall 5: Avoiding Individual Projects**

The survey of different simulation course syllabi found that they typically included a large group project component. Many of them followed a format of having smaller projects and homework assignments as individual projects, but the course culminated with a group project. This group project often related to creating a fairly detailed simulation with a substantial output analysis component. The reason for the group project typically stems from an engineering program's requirement to include an objective related to performing as part of a team. Additionally, it is well documented that group projects provide several non-technical benefits (Chandrasekaran, 2012; Colbeck, 2000; Dutson, 1997). Another benefit of group projects is that they are easier for instructors to grade, especially later in the semester when instructors have many competing requirements.

However, group projects have a few issues. The first is the "free-rider" phenomenon, where some members of the team do not contribute, yet they get the same overall grade. This issue is often resolved through peer evaluations, where team members can evaluate each other's contributions (Hall, 2012). The second, larger issue is the "divide and conquer" approach, where teams divide up the tasks such that one person builds the simulation, one person performs the output analysis, and one person writes up the results. In this case, peer evaluations do not capture the segmentation of the work, yet each student is not actively taking part in the development of the simulation.

As such, many simulation courses use exams to assess individual students' simulation skills, especially towards the end of the semester. Exams in simulation courses are coupled with a number of intrinsic issues. First, simulations take time to develop and build. As such, for a timed exam, students are typically not expected to build a substantial simulation that represents the body of knowledge from the semester. Second, exams typically cover a large amount of knowledge-based questions, having students define key terms and discuss qualitatively how to build a simulation. However, simulation courses are typically methodology courses; as such, the assessment should be more skill-based than knowledge-based. Third, due to test-control and infrastructure availability, some of the exams are limited to paper and pen, foregoing the use of computers.

Individual projects, especially for final course projects, have several advantages over the current scheme of group projects coupled with exams. Foremost, individual projects require every student to design and build a simulation of substance. Second, the projects are a developing experience, where students learn from the project while also being assessed.

Prior to AY2018, SE485 used a traditional group project coupled with a final exam, where each assignment was worth 20 percent of the course grade. The group project required the team to perform a detailed design of experiments using IWARS. The final exam was paper-based and assessed how well students were able to define key terms, qualitatively describe the benefits of simulations, and perform output analysis. It did not require students to build simulations. In AY2018, the final exam was changed to be computer-based, where students built two different simulations. Students found that this test better aligned with the course material than in previous years.

In AY2019, SE485 moved away from a group project and final exam in favor of a culminating individual project. This project involved a substantial literature review component, where students had to determine how to model the effects of a cyber-attack at a tactical level. It also required students to build detailed scenarios in IWARS using features not previously discussed in class. Based on course-end feedback, students preferred this approach relative to those used in previous years.
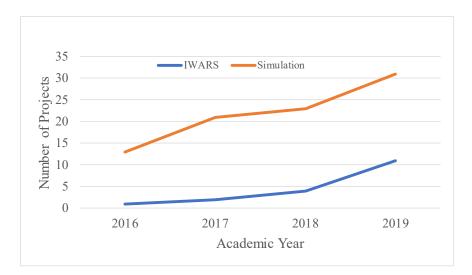
## ASSESSMENT OF TECHNIQUES

Changes were implemented in SE485 during AY2018 and AY2019, and several different formal and informal assessment techniques were subsequently used to assess the effects of these changes. The most standard assessment technique is course-end surveys where students anonymously answer questions at the end of each semester to assess how well the course supported the department's overall objectives. In general, the questions have students rate how well they agree with a statement on a scale from 1 to 5, with a score of 5 representing strong agreement. The set of questions and average results from AY2016 to AY2019 are shown in Table 2.

**Table 2: Course-end survey results from AY2016 to AY2019**

| | Question | AY19 | AY18 | AY17 | AY16 |
|---|---|---|---|---|---|
| 1 | This course helped me learn to design, manage, or reengineer systems or processes. | 4.16 | 4.07 | 3.88 | 3.91 |
| 2 | This course taught me to communicate effectively both orally and in writing. | 4.21 | 4.19 | 3.92 | 4.01 |
| 3 | This course improved my ability to solve real-world problems through quantitative techniques. | 4.25 | 4.18 | 3.87 | 3.95 |
| 4 | This course provided me with practical, problem-solving experiences applicable to my future as an Army officer. | 4.16 | 4.08 | 3.72 | 3.75 |
| 5 | Course exercises and designs were realistic experiences that enabled open ended analysis, design, or implementation of systems. | 4.23 | 4.26 | 4.03 | 3.97 |
| 6 | This course has motivated me to pursue deeper learning in related systems engineering or engineering management topics. | 4.02 | 3.94 | 3.61 | 3.45 |
| | Number of students filling out course end-survey | 44 | 34 | 38 | 38 |

The general trend from the course-end surveys indicate that the course is better meeting program objectives, and that the course is continuing to improve. A standard t-test was performed to identify the significance of changes in the course-end survey feedback between AY16 and AY19. An analysis of these results indicates a significant increase in the students' perception of how well the class met all six program objectives. In particular, the surveys indicated a very large increase in how well the modified course promoted lifelong learning (Question 6).

Since anonymous course-end surveys have inherent limitations, cadets were also interviewed to capture their thoughts on the course project. One student stated, "It was fun applying academic material to the real-world. I haven't gotten to do that in other courses." A second student stated that she felt "developing simulations to solve Army problems was exciting." Finally, a third student commented that his roommate was jealous of him, because he got to work on "real-problems." The bulk of the students echoed these sentiments.

**Figure 3: Number of capstone projects and honors theses that used simulation and IWARS from AY2016 to AY2019**

Another significant metric for evaluating the efficacy of this analysis is looking at the number of honor theses and capstone projects that elected to use IWARS over past years. Since SE485 is taught during the fall semester, students have the opportunity to apply their simulation skills to their capstone projects, which run all year, as well as their honors theses, which are written in the spring. These projects are student-led, such that they have the freedom to choose the appropriate tools for their analysis. Figure 2 plots the number of projects for AY2016 to AY2019 that incorporated different simulation packages, in addition to those that used IWARS. The plot shows a steady increase in the number of projects that use simulation, with a substantial increase in the number of IWARS-based projects. In particular, multiple students enrolled in SE485 saw IWARS as an opportunity to perform meaningful analysis for their honors thesis. Students looked at a range of topics including the integration of new technology into small Army units, trade-space analysis in assault weapon design, and soldier performance models (e.g., Allen et al., 2019; Banga and Lesinksi, 2019; Cascio et al., 2019; Gabrovic et al., 2019; Gabrovic and Mittal, 2019; Price and Mittal, 2019). The increased usage shows that students better appreciate M&S, and IWARS in particular, as a tool for system analysis and design.

**FUTURE OF SIMULATION COURSES IN THE CLASSROOM AND LOOMING PITFALLS**

As M&S technology continues to evolve, M&S courses can be expected to play a much larger role in undergraduate engineering curricula. As such, M&S courses have the potential to be moved from a senior-level course to an introductory-level course, as shown in Figure 4. Other courses, including the foundational knowledge courses, can then utilize M&S to teach and apply the course concepts.

Not only does this shift in the role of M&S allow students to develop better simulation skills, it negates several of the aforementioned pitfalls. First, since foundational classes will be taught after the M&S course, students will have the opportunity to develop methodologies in those classes, negating the first pitfall. Second, tutorials will be more appropriate for this type of teaching paradigm, since students will have numerous opportunities to apply M&S in future classes, hence negating the second pitfall. Third, by the very nature of using M&S to teach other courses, the third pitfall is negated.

However, the remaining two pitfalls will become even more important. First, individual assessments are necessary, since the impact of individual students not learning M&S will propagate throughout the educational experience. Second, the need for V&V becomes significantly more important, since bad M&S skills can negatively impact a student's ability to understand key engineering concepts.
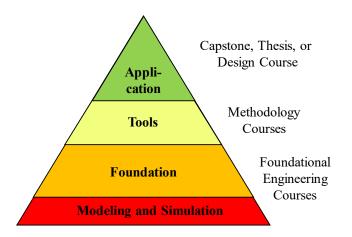
**Figure 4: Projected structure of engineering curricula as M&S continues to advance**

**CONCLUSION**

The growing need for junior engineers to be proficient in M&S has shifted undergraduate M&S courses from covering a broad base of concepts to focusing on teaching a particular software package. This change is necessary to ensure that academia is providing their graduates with the skills that they will need in industry. However, as the courses become software-centric, it is necessary to avoid a number of pitfalls. The first major pitfall is focusing on the tool or software without properly teaching the underlying methodologies. This pitfall can result in students becoming fixated on the software, limiting their broader knowledge of M&S. The second pitfall involves the use of contrived, academic tutorials as course projects, which prevents students from fully understanding the simulation design process. The third and fourth pitfalls are only superficially covering V&V and not building on material that was taught in previous classes. Finally, the fifth pitfall is the over-reliance on group projects and tests over individual projects.

These pitfalls were uncovered when updating SE485, a combat modeling course at USMA. The course adapted its structure and content in AY2018 and AY2019 to avoid these pitfalls, with several lessons learned that are applicable to the broader simulation education community. Generally, students gained a broader understanding of M&S and submitted higher quality work. Additionally, the course-end feedback found an overall increase in M&S knowledge, with many students choosing to use M&S to support their honors theses and capstone projects, a trend not seen in past years.

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