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INCORPORTATING VIDEO MODULES IN SIMULATION EDUCATION

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ABSTRACT

This paper describes the use of video modules to improve learning opportunities in university courses and commercial training courses on discrete-event simulation and data analytics. The paper gives the chronology and describes the resulting work products from our use of video modules since 2011. It also describes our methodologies and lessons learned for selecting topics for video modules, creating the individual videos, and creating/maintaining the hosting website. We also provide the perspective of a user not involved in the development. While this paper does not provide a rigorous scientific analysis of the methods or resulting impact on learning outcomes, we hope that anyone interested in developing and using video modules to augment their classes will find the general information useful.

1 INTRODUCTION

This paper and the corresponding conference presentation describe our use of video modules to improve learning opportunities in my undergraduate and graduate-level courses on discrete-event simulation and data analytics. Our objectives are to describe the processes that we use along with our general observations, opinions, and recommendations based on many years of experience. Most of the paper is written in the first-person voice with Sections 1, 2, and 3 from the first author and developer of the video modules and Section 4 from the second author – a consumer/user of the video modules in several contexts.

Based on over 30 years of experience teaching university and commercial courses involving computer applications and programming, it is clear to me that students benefit from an environment where they can repeat, skip, slow down, and speed up the coverage of much of the material covered in these courses. This is especially true of the material that involves working directly with the computer (like building Simio models). In this environment, students can work at their own pace and repeat as often as necessary, which leads to enhanced learning opportunities.

In general, I have found that the students in my classes can be roughly partitioned into three groups: One group that is perfectly comfortable and enjoys interacting with the computer and exploring on their own; another group that is reasonably proficient and not intimidated but does not generally explore beyond the specific material being taught; and a final group that finds computer interaction difficult, and members are often intimidated when faced with a computer task. Note that this partitioning is not based on a formal assessment but rather it is based on observation and interaction with the students over time. In a synchronous teaching environment (i.e., a combination of lecture and "follow me"-type instruction with an application), teaching to any one of the three groups is not difficult, but teaching to all three groups in the same class is not particularly good for overall learning. If you focus on the first group, the second group will have difficulty keeping up, and the third group will be lost. Similarly, if you focus on the second group, the first group will be exploring on their own or will be bored, and the third group will find it difficult to keep up. If you focus on the third group, the first group will be completely bored, and the second group will be somewhat bored or focusing on other things. One of the motivations for having laboratory components of computer-related courses is to address this issue by providing an environment with smaller group sizes (often self-selected) and more access to instructors/teaching assistants for individual assistance.

The approach that I have found to be most effective at addressing this issue is to separate the conceptual and foundational material from the "computer-interaction" material and to focus on the conceptual and foundational material in a lecture environment and use short, narrowly focused video modules to cover the "computer-interaction" material. This paper describes my approach to doing just that. Note that this paper does not provide a rigorous scientific analysis of the methods or results but is instead a collection of my opinions based on experience, along with the supporting descriptive materials. This is the type of paper/presentation that I would have liked to have had when I started developing and using video modules 13 years ago.

This paper is organized as follows. The next section provides a chronology of the development of the methods that I use and the resulting video module series (work products). Section 3 focuses on the methodologies themselves. Section 4 highlights a user's perspective. Section 5 provides the conclusions and discusses future work.

2 CHRONOLOGY AND WORK PRODUCTS

My journey began in 2011 when I noticed students using Kahn Academy (https://www.khanacademy.org) videos for math and statistics-related topics (see Table 1 for the full chronology of my journey and Table 2 for details about the work products created). I was immediately struck by the simplicity and narrow focus of the videos and after doing some research into the Kahn Academy and its origins, it seemed clear that something similar focusing on the materials in my classes would be very helpful. The initial development of a set of videos was one of the foci of my sabbatical in 2012, resulting in the development of the *Flexible Manufacturing Cell (FMC) Simulation with Simio RPS* video series and the initial planning of the *Learning Simio Lab Series*.

Also, during this sabbatical, I enrolled in three Coursera courses focusing on programming and data analytics. The global availability of the Coursera courses (and other Massively Open Online Courses – or MOOCs) and their common structure and high-quality content made them quite useful, and it seemed that this general model of video-based asynchronous instruction and learning was here to stay. However, while the typical MOOC model is fantastic with its availability-to-all model, the lack of direct instructor-student interaction limits its effectiveness in many cases, especially in highly specialized topics like discrete-event simulation. The *Learning Simio Lab Series* was meant to address this issue by combining short, topic-based video modules with traditional lecture-based courses to serve as the primary material in the laboratory component of those courses. In this model, the students individually choose whether to complete the video module-based lab work on their own or during regularly scheduled lab sessions, where teaching assistants and/or instructors are available to answer questions and otherwise assist.

Table 1: Chronology of development.

Year	***Development***
2011	Noticed students using Kahn Academy videos and experimented with making similar format/length videos for simulation.
2012	Sabbatical year, Coursera courses, Developed the *FMC Simulation with Simio RPS* series.
2013	Developed the *Learning Simio Lab Series.*
2015	Simulation and Simio project and corresponding video modules.
2016	INSY 3010 (Programming and Database Applications for IE) modules.
2018	Developed *Learning Simio Fundamentals* training course.
2019	INSY 6500 (Modern Tools for Data Analytics and Modeling) modules.
2020	Developed modules for *Learning Simio: Advanced Use of Features* and *Learning Simio: Fundamentals of RPS* training courses.
2022	INSY 6450 (Simulation-based Planning and Scheduling) lectures + video modules.

The *Learning Simio Lab Series* was well received, and by 2015, at least 5 universities were using it to support their simulation courses. I have anecdotal information that more universities/people are using the series, but there is no easy way to collect accurate, verifiable user statistics, and I have chosen not to use a "registration model" where users must register and use individual logins to reach the material. While having the usage data would be nice, the overhead for administering this type of system made it impractical. YouTube provides one set of quantifiable usage information. The series includes 59 individual videos, which have had 356,106 views and 35,758 hours of watch time as of April 30, 2024. The other non-scientific piece of usage information that I have is the speed with which I was notified by multiple users all three times the website suffered a major outage.

Next up in 2015 and 2016 included the *Simulation and Simio* project, which led to the development of 30 or so individual videos, but no "named series", along with the development of supporting video modules for our undergraduate course on Programming and Database Applications for IE (INSY 3010). The simulation videos are included in the General Simulation Modules section referenced in Table 2 and the INSY 3010 modules are included in the Analytics Courses Modules section. The INSY 3010 modules turned out especially useful. In my experience of teaching programming fundamentals to IE students (through iterations of C, C++, Java, Visual Basic, and Python), many students who struggle, struggle with the initial "setup" and "overhead" – i.e., getting the computer set up, doing the initial configuration for the compiler, and getting the initial Design-Edit-Compile (where necessary)-Run loop down. Once students cross these hurdles, most do fine with the rest of the material, but if they do not get these fundamentals down early in the course, they generally struggle for the rest of the semester. These are exactly the types of topics that are ideal for video modules since the pace is 100% user-defined, and students can pause, rewind, repeat, or speedup or skip videos as their individual needs dictate. While these modules are not directly related to simulation, I learned a great deal about which material works well for video modules and which works better in a lecture environment, and I was able to apply this knowledge to my simulation-related course development and the other materials in Table 2.

Table 2: Work products.

Name	***Description***	***Link/Availability***
FMC Simulation with Simio RPS	An 11-video series illustrating the use of a simulation model for design optimization and for operations scheduling.	https://jsmith.co/educational-modules/flexible-manufacturing-cell-fmc-simulation-with-simio-rps/
Learning Simio Lab Series	A 13-module (with 4-5 videos, each) series designed to be the lab component for a one-semester introductory course in discrete-event simulation.	https://jsmith.co/educational-modules/learning-simio-lab-series-lsls/
Analytics Courses Modules	An 8-module (with 3-4 videos each) series focusing on tools and concepts for data analytics for Industrial Engineering students.	https://jsmith.co/educational-modules/analytics-course-modules/
General Simulation Modules	A set of modules covering miscellaneous topics related to discrete-event simulation.	https://jsmith.co/general-simulation-modules/
Learning Simio Fundamentals	A 14-module training course targeted for users new to Simio.	Email academic@simio.com for information/access.
Learning Simio: Advanced Use of Features	A 9-module training course focusing on advanced topics/methods in Simio.	Email academic@simio.com for information/access.

Learning Simio: Fundamentals of RPS	A 9-module training course focusing on the tools and methods for simulation-based scheduling using Simio RPS.	Email academic@simio.com for information/access.
Simulation-based Planning and Scheduling Course	Recordings and video modules from a 1-semester graduate class on Simulation-based Planning and Scheduling	https://jsmith.co/insy-6450/

The next major development was the video module-based version of the *Learning Simio Fundamentals* training course in 2018. The original training course on which the video module series is based was a 4-day course designed to be presented in a synchronous environment, typically on-site with one or more instructors. This course was given in academic and industry settings many times over several years and the course materials were continually refined over those years. The course material focused almost exclusively on "How to use Simio," including many hands-on workshops and very little coverage of general simulation concepts. The video module-based version includes 14 modules with a total of 105 individual videos. The second and third courses in the Learning Simio sequence (*Advanced Use of Features* and *Fundamentals of RPS*) also focus on the "How to use Simio" but were not based on existing course materials and have only been offered in the asynchronous video format. The *Learning Simio* video-based courses have been most successful when used in conjunction with lectures on fundamental simulation concepts (modeling, input/output analysis, experimentation, etc.) or for students that already have this general knowledge – they are not designed to be a complete, stand-alone solution for teaching simulation with Simio.

In 2019, I augmented the *Analytics Course Modules* with several videos from our Modern Tools for Data Analytics and Modeling course (INSY 6500). These modules focus on Python and R tools for data manipulation, visualization, and modeling. While these videos were designed for use in the analytics class, I also frequently reference them in my graduate simulation courses when discussing data manipulation, input/output analysis, and experimentation, and I use them as "extra reference material" in my undergraduate course. Focusing on making modules topic-specific and stand-alone where possible makes it easier to use the video modules in different classes. This was an important lesson that I learned from the initial *Learning Simio Fundamentals* modules, where I did a straight translation of the synchronous course into video modules, so picking out individual videos on specific topics to use outside of the course is difficult.

Finally, in 2022, I developed the video materials for our course on Simulation-based Planning and Scheduling (INSY 6450). This course has our introductory simulation course as a prerequisite and focuses on using simulation (and Simio's RPS functionality) to do production planning and scheduling. The unique aspect of these materials comes from the course structure – each week included 1 lecture and 1 video module (often including multiple videos) – and the fact that the recorded lectures and video modules are available at the link shown in Table 2. As with the other work products, I tried to make the 8 video modules with this course also useful as stand-alone modules on specific topics so that they can be shared individually in addition to as part of the INSY 6450 course.

3 METHODS

In this section, I discuss three basic issues associated with using video modules: selecting topics for video modules, creating the videos themselves, and creating/maintaining the hosting website and streaming method. Regarding creating video modules and creating/updating the website hosting the videos, my general mantra has been that quantity trumps production quality. While the content absolutely must be correct and hopefully concise and easy to follow, I do not find it productive to "fine tune" the content and perfect the video quality, script/presentation, or text descriptions on the hosting website beyond the "generally acceptable" level. This is simply a resource allocation decision. If it takes 8 hours to create a generally acceptable video and 16 hours to create a video with the same content but better production

quality, I choose to create two videos in the 16 hours, thereby effectively doubling the amount of generated content.

3.1 Selecting Topics for Video Modules

I've spent most of my time developing video modules that augment "live" lectures and or Q&A sessions rather than stand-alone video-based courses. This is an important distinction as my task is to select *which* specific material to cover using video vs. covering in the live lectures and Q&A sessions rather than *how* to cover all the material in a course. I have found video modules to be most effective for material that involves working with a software application (like Simio, Jupyter, or RStudio) where the instruction involves following a sequence of steps in the application.

As an example, consider the single-server queuing system and the Simio model shown in Figure 1 (from Smith and Sturrock (2021)). In teaching this material, I find that the most effective method is to discuss the concepts of a single-server queueing system (entities, arrivals, service, departures, queueing, performance metrics, etc.) and to show the Simio model in a lecture format that promotes discussion, and to use a video module to demonstrate the step-by-step development of the model in Simio. This allows the students to think freely during the lecture portion since they know that the step-by-step instructions are in the video module. In the subsequent lecture, I then discuss the technical details of the Simio model that the students saw in the video module (and hopefully used while following along with the model development).

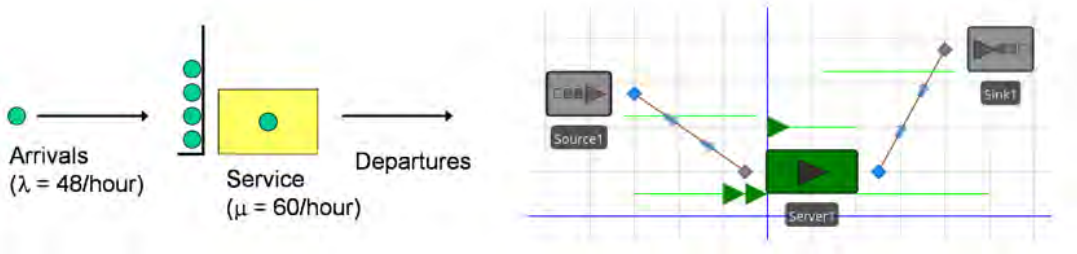

Figure 1: Single-server queueing system – abstract model (left) and Simio model (right).

I have also used the "follow-me" method of building the model in class or in the lab while the students follow along on their own computers. Except in classes of less than 5-ish students, I find this method inefficient and ineffective. As discussed earlier, some students will be bored (ready to go faster), and other students will be lost (and often too shy to say "slow down" or "please repeat"). The key here is to keep the material that will likely generate questions/discussions in the lecture and to focus on the primarily rote material and especially the material that involves direct interaction with Simio in the video modules.

The single most important thing I've learned about selecting topics for video modules is that focusing modules on narrowly-define topics and, to the extent possible, making the modules "self-contained" increases their usefulness. As a specific example, consider the initial transient period in a simulation model. The three general topics that I cover in classes are: Defining the initial transient period; Methods for mitigating the initial transient period (i.e., a warm-up period); Determining when you should mitigate the initial transient period (e.g., steady-state models) vs. when is the transient period a fundamental part of the analysis (e.g., terminating models). Rather than creating a single video module covering all three topics, I would have three individual modules. For my introductory simulation class students, I would assign all three modules in sequence, whereas if someone asked me, "How do I implement a warm-up I Simio," I would refer them to the second module, and if someone asked me, "When do I want to use a warm-up period", I would refer them to the third module. By structuring the modules this way, you can always have the linear sequence that you would want in an introductory course, but you're not limited to that sequence, and it is easy to pick and choose by topic in an à la carte fashion.

3.2 Creating/Maintaining the Video Modules

There are many screen recording software tools, and my choice (Camtasia ®) was not based on a comprehensive comparison between available software, but rather, it was based on a very short comparison of features and costs. Further, given my relatively simple needs, I have seen no reason to re-evaluate. Finally, the general development methodology that I use and will describe here can be used in virtually any screen recording software. My process is as follows:

1. Decide on the main topic to be covered and develop a preliminary outline. This includes deciding on the "starting" and "ending" places for the module (i.e., what do you expect students to know coming into the module and what do you expect them to learn during the module).
2. Add detail to the outline and start to estimate the length of time required for each section. I aim for each video to be 12-15 minutes long (although this is not a hard-and-fast rule).
3. Once the detailed outline is complete, I know how many videos will comprise the module.
4. From the outline, I create a PowerPoint presentation that will include the title slides for each video along with any content that is better presented in text/picture form than in the target software package (Simio, for my simulation classes).
5. I then do a final review using the Powerpoint presentation and outline notes. Once I am satisfied, I start making the individual videos. For each video, the process that I follow is:
   (a) Further refine the outline, including "scripting" the first couple of minutes of the video. I've found that when I do not do this, I often must re-record the initial segment several times.
   (b) Create a Camtasia project for the video and organize the file directory structure.
   (c) Record the individual video segments. A typical 15-minute video will have between 5 and 10 segments, but the actual number really depends on the material being covered. If the segment involves modifying a Simio model (or other program file), I make sure to save "before" and "after" versions of the model so that I can easily go back, if necessary.
   (d) "Produce" the video file.
   (e) Review the completed video and edit as necessary.

Things I've learned while making video modules:

- Leave 1-2 second gaps in the videos while recording – it seems uncomfortable at first but makes it much easier to cut and splice, where necessary. Avoid the temptation to immediately stop recording when you're finished talking – it's quite simple to cut out unnecessary gaps once you are satisfied with the video segment.
- Keep intermediate versions of Simio models (or whatever package you are using) in case you want to go back and reshoot individual video segments.
- Always keep the raw video files – I have gone back many times and fixed errors/omissions that were reported by users well after the videos were initially released. I keep the raw video files in separate folders for each video module (which is not the default mode for Camtasia) just for this reason.
- For an individual video, the best prep time-to-record time ratio is approximately 4-to-1. Any less prep and I ended up re-recording material multiple times where the planning was insufficient.

Maintenance of the video modules primarily consists of fixing errors/omissions when they are identified and editing/augmenting video modules when necessary due to software updates. The first three bulleted items above help with editing modules to fix errors and address omissions. Changes in the software can also "date" video modules. This can range from minor, mostly cosmetic differences between what the user sees in the software and what is shown in the video to major differences where new or updated features

in the software conflict with what is illustrated in the videos. I largely ignore the cosmetic differences (for example, the Simio UI has changed substantially since the *Learning Simio Lab Series* was recorded) and simply leave a note indicating that the visuals might not match exactly, but this only works when the functionality is not impacted.

Major software changes must be dealt with on a case-by-case basis. For example, an early lab video module illustrated how to implement balking and reneging by adding user logic to a standard Simio Server object, but a later version of Simio implemented the balking and reneging logic as part of the standard Server object. In this case, I chose to add a note indicating the new Server functionality and augmented the lab assignment so that students use both methods for balking/reneging – the original user-logic method that would apply to other simulation software and the Simio-specific version using the new Server object functionality. On the other end of the spectrum, when Simio completely changed the method to interact with external data sources, I completely redid the corresponding video module since there was no simple way to "fix" the existing video.

3.3 Creating/Maintaining the Hosting Web Site

As with the screen recording software, the choices for hosting software are many. I currently use a WordPress (https://wordpress.com/) site with individual videos hosted on YouTube (https://www.youtube.com/). Ease of development and maintenance is my primary concern here, and WordPress offers a wide range of options for style, user-interaction functionality, and reporting (most of which I do not use). In addition, there are many options for paid hosting/maintenance services. I used a home-grown content management system and Drupal (https://www.drupal.org/) in previous incarnations of my site, and so far, WordPress has been the easiest to develop and maintain.

Things I've learned about the hosting site development/maintenance:

- Simplicity of maintenance and expansion trumps sophisticated design.
- Getting reliable use statistics is very difficult.
- Users rarely provide feedback unless the site is down (and then feedback is immediate).
- Pay attention to routine site maintenance – the three major outages of my site were direct results of me not paying attention to maintenance tasks even though the hosting service frequently reminded me.

4 USER PERSPECTIVE

As an undergraduate student, graduate student, teaching assistant (TA), and instructor at Auburn, I have had the opportunity to use these video modules in some way during each stage of my journey. From my experiences, I can provide a perspective on the strengths and benefits of the video modules and some aspects that should be considered when using this method. Before outlining my experiences, it is important that the readers have some background information about me so they can use this information to understand my perspective. I was in middle and high school when video platforms like Khan Academy and Crash Course became popular, so I used these platforms whenever I needed a quick material review. I appreciated having access to sources that could answer my questions without waiting to talk to the teacher. I continued to use these resources in college and found other online teaching materials to teach myself more effectively. I fall into the category of students who are comfortable with computers and enjoy exploring independently. I enjoyed my programming classes and was successful in them. Even though I did not struggle with these concepts, I tutored students who needed extra time and guidance to grasp topics.

During my undergraduate studies, I was exposed to video modules in class through the Simulation and Simio project, where specific videos were assigned from this series to teach concepts needed to complete a lab assignment. Using this method, I got a good foundation in Simio, which allowed me to build a Simio

model for a graduate student as part of undergraduate research (Evans et al. 2021). The videos were also beneficial for studying for the tests. I did not have to remember how to do specific pieces in Simio or write down steps because I could reference the videos whenever needed. Although I did well in the class, one aspect could have been improved. Whenever I had any questions about video content or the labs, the TA could not answer them clearly. Even though the videos handle a large part of the teaching, the professor and TAs must be knowledgeable about video content. Professors and TAs with experience can clarify content that is still confusing or warn students of common mistakes.

I started graduate school in the Fall of 2020 during COVID-19 restrictions. I took a Data Analytics and Modeling class with Dr. Smith this semester, which was only the second time the course was taught using video modules. Videos were either assigned for the class to learn specific content or were just available if we needed further reference. My experience with this class was very similar to my experience as an undergraduate. The videos were great to reference as many times as needed. I will still reference some of these videos when remembering to use some of the class content for research or other classes. In Spring 2022, I was in the first Simulation-based Planning and Scheduling course offered at Auburn. The videos from this class were my favorite of the three classes with video modules. I had been independently advancing my Simio abilities with only guidance from forums and the Simio reference guide. This was the first time I saw someone with advanced modeling skills implement some of the concepts I had tried to do independently. I told multiple people that after taking this course, I would have been able to build a much better model for my undergraduate research. I often share these videos with students trying to build advanced models.

Switching from a student perspective to a teaching perspective, my first semester as a TA for Auburn's simulation course was in the Spring of 2021. The course was held entirely online for the first week of class. After the first week, the lecture room was not big enough for social distancing requirements, so the students had to be split into two groups. One group would attend an in-person class on one day and watch a video lecture the other day, while the second group did the opposite. Given the concerns that the quality of student education would decline because of COVID-19 forcing different course modalities, the professor of this class wanted to record his own video lectures to reduce that feeling. Also, the videos that had been used in the class were more difficult to locate due to issues with Dr. Smith's video platform. The new video lectures were inspired by the content in Dr.Smith's videos but tailored for the new class structure. We had in-person lab sessions, so I was able to observe that students were still able to succeed with the material.

After my first semester as a TA, I was given the opportunity to develop more content for the simulation course that would be implemented in the Spring of 2022. I further refined these materials and developed more content implemented in the Spring of 2023. This new content varied from the original video series used for course development. Also, the layout of Dr. Smith's content had changed due to the website change. At this point in academics, many students had spent a few years learning through Zoom classes or recorded videos. These factors pushed the professor and me to develop live lecture content instead of videos. We would still show the students how to access video content as an extra resource for those who needed more help. Lab attendance was not required, and students could use the resources on the site to succeed in class if they did not want to attend the lab class.

In the Fall of 2023, I was the instructor of record for the simulation course. Being an instructor and a TA gave me a completely new view of video modules. First, video modules increase the accessibility of course content to serve students with various needs. Students who get sick and cannot attend class do not have to rely on classmates' potentially imperfect notes. They can watch the videos as they recover and do not necessarily have to spend more time in office hours to catch up. There are many resources available to add captions for students with hearing disabilities. Students with other various learning struggles can work independently with the videos. Although video modules can be helpful for some learning struggles, it is important to remember that other students may struggle more with videos because it may be easier to pay attention in a lecture versus a video. This issue could be due to COVID-19 changing the education landscape for many students. Secondly, using video modules creates consistency between different TAs and different semesters. Some of the TAs for courses may not be as gifted in teaching and communicating materials as

others. Video modules can mitigate the struggles of finding TAs who can effectively teach content. The video modules can also be used to train TAs instead of placing this responsibility on senior TAs or professors.

Overall, I believe video modules can be beneficial if carefully and thoughtfully implemented. As a potential future faculty member, I plan to incorporate video modules in classes, especially software-based classes. Using the lessons learned presented in this paper will make the development process faster and smoother. It would also be nice to use video modules developed by others while I take the time to develop my own. This requires cooperation between faculty among universities as they must be willing to share their content with whomever or offer deals to other faculty.

5 CONCLUSIONS AND FUTURE WORK

We firmly believe that using video modules in conjunction with synchronous lectures/Q&A sessions will continue to increase in popularity and improve overall education/learning in technical courses. This paper and the corresponding conference talk present the chronology and work products generated in our journeys since 2011, along with our general methods and lessons learned for selecting material for video modules, creating the individual videos, and creating/maintaining the hosting website.

As for future work, we continue to add individual modules to the *General Simulation Modules* and *Analytics Courses Modules* collections shown in Table 2, and we're planning a significant update to the *Learning Simio Lab Series* to incorporate the latest Simio version and to align with the new edition of Simio more closely *and Simulation: Modeling, Analysis, Applications*, due in July 2024 (Smith and Sturrock 2021). Finally, we are completely redoing the *Learning Simio* series (*Fundamentals*, *Advanced Use of Features*, and *Fundamentals of RPS*) to make the modules more topic-focused and less linear so that it will be easier for users (commercial and academic) to pick and choose the topics of interest to them.

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