From Simulation to Capstone: Implementing Virtual Autopsy Software in Forensic Science Education

Darlene Brothers-Gray[1]*, Wendy Velez-Torres[2]

[1]Department of Criminal Justice, College of Behavioral and Social Sciences, Coppin State University, 2500 W. North Avenue, Baltimore, Maryland 21216
[2]Department of Information Technology Division, Senior Instructional and Digital Accessibility Specialist, Coppin State University, 2500 W. North Avenue, Baltimore, Maryland 21217
**Corresponding author: dbrothers-gray@coppin.edu*

Abstract: Virtual autopsy simulations integrated into forensic science education programs can transform student engagement and learning outcomes. This study evaluates survey results, grade performance, and qualitative insights from a six-week simulation program, highlighting its impact on skill development and student engagement. Data was gathered from student surveys, grade outcomes, and the Learning Mastery Report within our Learning Management System during the first year of implementation. The findings demonstrate that the simulation effectively helped students better understand course content by bridging theoretical knowledge with practical application through realistic, hands-on forensic scenarios. This immersive approach serves as a viable alternative to traditional morgue visits, addressing logistical challenges while maintaining educational rigor.

Keywords: autopsy, death investigation, digital capstone, virtual autopsy simulation

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Introduction

Coppin State University's Virtual Reality Innovation Lab, established in 2018, serves as a campus-wide resource for integrating advanced technologies into education. The lab supports innovative teaching practices and provides students and faculty with immersive learning experiences across various disciplines, including forensic science. Since its inception, students have used the lab in forensic courses primarily to explore crime scenes through virtual reality (VR) headsets and glasses. However, the lab had not previously been utilized for interactive desktop simulations. This foundation enabled the implementation of an Autopsy Simulator in the Graduate class CRJU524 Death Investigation course, expanding the lab's use to include advanced, scenario-based learning tools. Students enrolled in this course are usually pursing careers as morgue technicians, death investigators or forensic nurses.

Traditional morgue visits were previously a core part of the CRJU524 course, offering students observation of an autopsy to improve anatomical knowledge, observation skills and developing connections between pathological disease (3). In the past, the autopsy was used as a valuable tool for teaching students but over the years professors have found that the autopsy is not as effective due to the decreasing percentages of autopsies, the time that is required to complete an autopsy, and misunderstandings concerning the directives in certain jurisdictions (3). As such, alternative teaching methods would be beneficial (4). At Coppin, morgue visits were plentiful, prior to the pandemic. Before they could complete the visits, the students had to fill out a waiver form releasing the University of any liability. During these visits, students were able to observe multiple autopsies and engage with the doctors and morgue attendants. While these traditional trips were valuable, they were limited to observation rather than hands-on participation.

Physical autopsies, though informative, restricted the visualization of organs, whereas simulated autopsies provide a more detailed and realistic view of the human anatomy (5). Students appreciated physical autopsies for teaching the structure of the human body and helping them process the emotions associated with death (5). However, simulations offered a different learning experience, emphasizing anatomical visualization without the sensory encumber often encountered in a morgue setting (5).

Once the pandemic hit, morgue visits were restricted and closed off for our students and have not yet re-opened for visits. Logistical constraints-such as conflicting work schedules of students – also made these trips difficult to arrange. Virtual methods can provide high-resolution, 3D visualizations of anatomical structures (5). To replace the in-person morgue visits, the authors decided to incorporate the Autopsy Simulator. The Autopsy Simulator is a realistic, interactive story-driven game simulation from Woodland Games that was created in 2024 with input from professional pathologists (**FIGURE 1)**. The virtual autopsy simulation provided students with forensic scenarios and structured guidance.

Through the simulation, students were required to perform virtual autopsies. Students selected the correct tools to dissect the body, made precise incisions, and examined all internal organs, dissecting them further to advance their investigations **(FIGURE 2)**. This option was not available for in-person visits at the morgue. In the past the students were able to go to an in-person visit but they were not able to participate in the autopsy. They just viewed the autopsy. Using the simulation allowed them to have hands on experience virtually. Throughout the simulation, students needed to be precise with their measurements and cuts; any errors would prevent them from progressing in the simulation to determine the cause of death.

The simulation was run on high-performance desktop computers housed in the Virtual Reality Innovation Lab. These computers were equipped with advanced graphics capabilities, enabling a highly immersive experience. Unlike virtual reality (VR) systems, this 3D desktop application provided an interactive environment without requiring VR headsets. Students navigated the scenarios using a keyboard and mouse, ensuring accessibility for all participants.

Figure 1 Image of a head saw being used to cut the head to examine the brain.

FIGURE 2 Students selecting which tool they need to look at organs using a computer mouse

The decision to incorporate the Autopsy Simulator into our course aligns with recent research that discusses the value of using digital tools for improving forensic education. Realistic digital simulations can effectively mimic real-world scenarios and enhance understanding (1). Mixed Reality technologies can replicate real-world forensic scenarios, offering both realism and accessibility, that deliver meaningful learning experiences (1-2,6). The use of the simulation enabled our students to actively engage in autopsy techniques within a controlled, repeatable environment, which fostered critical thinking and practical skill development (6). Feedback from participants in similar research, as well as our own students, underscores the effectiveness of such simulations in promoting deeper understanding and honing essential forensic skills (1,6) These insights guided the integration of the Autopsy Simulator into the course's curriculum.

Implementation of VR Autopsy Simulation

CRJU524 Death Investigation is traditionally a 15-week program. As part of our initial pilot, 10 graduate students participated in a six-week simulation program where they investigated six cases. Graduate classes at Coppin are typically capped at 11 students, making this small sample size ideal for refining the process and assessing the feasibility of larger-scale implementation. The cases covered diverse causes of death, including blunt force trauma, drowning, suicide, and accidental overdose. Each case presented unique challenges,

requiring students to critically analyze evidence and document their findings. For instance, in one case, students identified fractures and tissue damage to determine the cause of death as blunt force trauma.

The simulation provided all case details, and we did not create the cases ourselves. For every case, students reviewed police reports, documented markings on the bodies, and ultimately determined the manner and cause of death (homicide, accidental, or natural) based on the information generated by the technology tool. Additionally, students completed actual autopsy forms—replicating those used in live autopsies—using the details provided by the simulation, ensuring a realistic and immersive learning experience (**FIGURE 3)**.

Due to the graphic and realistic nature of the simulation, students were required to complete a waiver form before engaging with the content. This requirement, established by the IT department at Coppin State University, serves as a precautionary measure to protect the university from liability in the event of any unforeseen issues. Such issues may include emotional or psychological distress, technical malfunctions, inappropriate use of content, legal or ethical concerns, or hardware or equipment failures. The waiver ensures that students are aware of these potential risks and proceed with informed consent, fostering a responsible and secure learning environment. This hands-on experience prepared them for the capstone project, which served as the final assessment of their skills and knowledge from the course.

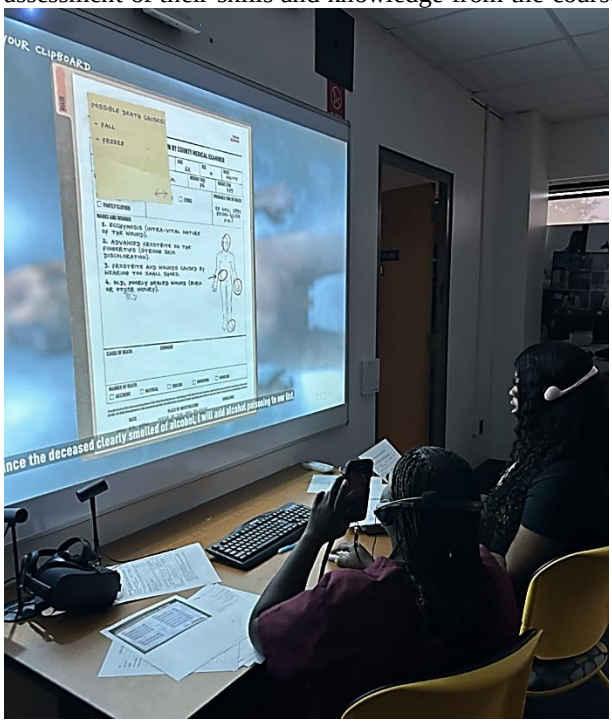

FIGURE 3 Students looking over the Autopsy Report in the simulation.

Development of a Digital Capstone

The digital capstone built upon the skills and knowledge students developed throughout the course and during the simulation. It required them to show their learning and demonstrate mastery of forensic practices.

The capstone assessment included a survey and seven mini-exams. The first exam focused on general knowledge and skills acquired throughout the course, ensuring a strong foundation in forensic practices. The remaining six exams were case-specific, assessing students' ability to analyze evidence and answer questions based on the simulated scenarios. This comprehensive assessment evaluated both procedural knowledge and case-specific skills while providing valuable insights into student performance and the pilot's effectiveness.

The capstone's components, except for the survey, were organized in Blackboard Ultra—our Learning Management System—and aligned with three of our General Education Outcomes/Institutional Learning Outcomes:

1. **Analytical Reasoning**
    - Thinking critically and analytically to address various issues and concerns.
    - Applying classical and/or current theories and principles from specific content areas.
    - Using critical judgments based on a combination of evidence and assumptions to reach viable conclusions.
    - Collecting, analyzing, and interpreting data through computational literacy and scientific reasoning.
2. **Critical Thinking**
    - Responding thoughtfully to issues and problems by applying classical and/or current theories and principles.
    - Making informed judgments by evaluating evidence and assumptions to draw logical conclusions.
3. **Quantitative Literacy**
    - Collecting, analyzing, and interpreting data using computational literacy and scientific reasoning.

The General Education Outcomes/Institutional Learning Outcomes were already in place before implementing the technology in the course. Previously, students were assessed through a traditional exam and a paper, both of which were aligned with these outcomes. With the introduction of the simulation, the same learning outcomes remained, but the assessment method evolved. While the original exam was retained, the paper was replaced with six mini-exams, each focusing on details specific to the cases students encountered in the simulation. This shift allowed for a more applied and

case-specific evaluation while maintaining alignment with our institutional learning goals

This alignment ensured that the capstone not only assessed students' forensic knowledge and skills but also supported the achievement of key institutional learning outcomes.

While the survey was not aligned, all seven exams (the original exam and the six mini-exams based on the simulation scenarios) were directly mapped to the outcomes using Blackboard Ultra's goal alignment feature. By aligning these assessments, Blackboard Ultra's Mastery tab provided detailed insights into student progress, tracking their performance against the learning objectives and generating reports that showed their level of mastery for each outcome (4).

- **Analytical Reasoning:** The six mini-exams required students to analyze forensic evidence from each scenario, review case details, and apply forensic theories to determine the cause and manner of death. These assessments ensured students demonstrated the ability to collect, interpret, and evaluate evidence logically.
- **Critical Thinking:** Questions in the six mini-exams challenged students to assess the presented evidence critically, consider alternative explanations, and justify their conclusions. Students had to distinguish between possible causes of death, such as homicide versus accidental death, using case details.
- **Quantitative Literacy:** The original exam included real forensic autopsy images, requiring students to analyze decomposition stages, injury patterns, and wound procedures. This assessment reinforced their ability to interpret forensic data and apply scientific reasoning.

By leveraging Blackboard Ultra's assessment alignment features, instructors could systematically measure how students met institutional learning outcomes and identify areas where additional support was needed (4).

Data Collection: Surveys, Grade Performance, Learning Mastery Report

To assess the effectiveness of the simulation and capstone project, the authors combined data from a student survey ,grade performance and the Learning Mastery Report within our Learning Management System (LMS), Blackboard Ultra. The survey, created using Microsoft Forms, asked questions about usability, engagement, and perceived skill development. Final grades were also analyzed to evaluate overall student performance. Additionally, the Learning Mastery Report in Blackboard Ultra was used to track how students progressed toward mastering aligned content and learning outcomes, offering detailed insights into their performance (4). "The Learning Mastery Report permits lecturers and scholars to evaluate the alignment of activities to the institutions' goals and learning outcomes. Mastery Level indicates the level of mastery for each student per each alignment. Performance Review indicates to the instructor how each student is performing alongside the alignments. A deeper analysis is provided in the individual student performance and simpler navigation by the surname can be provided by sorting" (4). This comprehensive approach ensured a multi-faceted evaluation of student learning, allowing for a more accurate assessment of the simulation's impact on academic achievement and skill development.

These methods together provided a clear and comprehensive understanding of how the simulations supported learning and skill development.

Results

The implementation of the virtual autopsy simulation in the CRJU524 Death Investigation course aimed to enhance student engagement, comprehension, and skill development. Feedback was gathered through the Virtual Autopsy Simulation Feedback survey to evaluate the effectiveness of the simulation pilot and identify areas for improvement. The survey was designed to gather detailed feedback from students about their experiences using the simulation tool. This survey consisted of a combination of multiple-choice, Likert scale, and open-ended questions aimed at assessing student engagement, usability, and the perceived impact of the simulation on learning outcomes.

Students were asked to indicate their familiarity with virtual autopsy tools prior to the simulation and to evaluate various aspects of the experience using a 5-point Likert scale, ranging from **1 (Strongly Disagree)** to **5 (Strongly Agree)**. This scale was used to measure agreement with statements related to the effectiveness of the simulation in enhancing understanding, engagement, and practical application of forensic concepts.

Additionally, open-ended questions provided an opportunity for students to share qualitative insights, including aspects they found most helpful, challenges encountered, features they enjoyed, suggestions for improvement, and memorable moments from the experience.

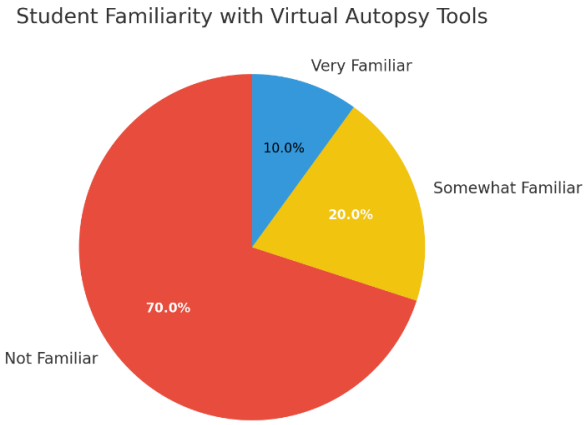

FIGURE 4 A pie chart showing the percentage of students who had familiarity with virtual autopsy tools prior to this course

Most students reported limited prior familiarity with virtual autopsy tools, with 20% indicating they were "somewhat familiar" and 70% "not familiar at all" **(FIGURE 4).** Only one student stated they were very familiar with such tools. This baseline underscored the novelty of the simulation and its potential to introduce students to advanced forensic tools.

The survey revealed that students found the simulation engaging and educationally impactful. When asked about the simulation's ability to enhance understanding, the majority strongly agreed, with responses emphasizing the immersive and interactive nature of the experience. Students appreciated specific features such as structured guidance, interactive 3D models (**FIGURE 5**), and the realistic portrayal of forensic scenarios. For example, one participant stated, "Manipulating virtual anatomical structures helped me understand injury mechanisms better than the textbooks ever could." Another noted, "A particularly memorable moment was identifying the cause of death through detailed organ analysis, which demonstrated the practical application of forensic techniques in an engaging way."

FIGURE 5 Image of a trachea being sliced in the simulation.

The survey responses provided valuable insights into the effectiveness of the virtual autopsy simulation in enhancing student learning and engagement. A significant portion of students (60%) strongly agreed, and an additional 30% agreed, that the simulation made the learning process more engaging than traditional methods **(FIGURE 6).**

Only 10% disagreed, suggesting that the simulation could be improved by adding more intuitive navigation controls and incorporating additional guided tutorials to help users quickly adapt to the interface. Overall, the results highlight the simulation's ability to foster curiosity and enthusiasm for learning while pointing to areas for potential enhancement.

The immersive nature of the 360-degree environment was particularly impactful, with 80% of respondents strongly agreeing and 10% agreeing that it enhanced their ability to analyze causes of death. An additional 10% were neutral. Similarly, 80% of respondents strongly agreed that the variety of cases explored during the simulation provided a comprehensive understanding of varying causes of death, while 10% agreed and another 10% remained neutral.

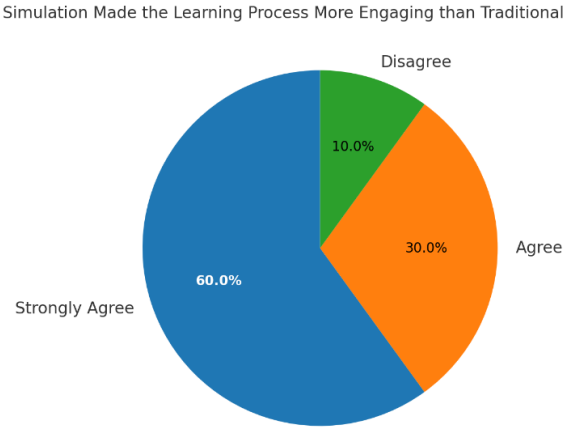

FIGURE 6 Percentage of students who found the simulation made the learning process more engaging.

Students noted the value of connecting theoretical knowledge with practical application. A combined 90% of students strongly agreed (70%) or agreed (20%) that progressing through the cases helped bridge this gap. Regarding the simulation's ability to demonstrate the complexities of autopsy procedures, 90% of respondents strongly agreed or agreed that the variety of causes of death effectively showcased these complexities. The 10% who disagreed suggested incorporating more diverse case studies and offering optional hints or explanations during complex steps to enhance accessibility and learning for users at all levels.

Skill development emerged as a key outcome, with 90% of students strongly agreeing that completing autopsy reports improved their ability to evaluate forensic

data critically. Additionally, students reported gains in confidence, with 90% strongly agreeing that their ability to interpret and report findings improved. Meanwhile, 10% of respondents remained neutral, highlighting room for potential improvement in the simulation.

Students overwhelmingly appreciated the interactive and hands-on aspects of the virtual autopsy simulation, noting how it deepened their understanding of forensic procedures and enhanced their learning experience. Several students emphasized that the simulation's hands-on nature made them feel as though they were actively performing the autopsy, which helped them grasp the procedural steps and practical skills required. One student remarked that "the autopsy simulation was very helpful in identifying causes of death" and understanding "the procedures needed to perform and complete the autopsies." Others highlighted the value of the narrator's detailed explanations, particularly when potential causes of death were analyzed and connected to specific findings, with one student stating, "The narrator would list potential causes of death and explain how it would've been caused in that specific case."

The inclusion of interactive 3D models was another feature students found particularly helpful. These models provided a clear and tangible understanding of anatomical structures in the context of the forensic cases, allowing students to analyze how injuries, trauma, and decomposition affected different body systems within each scenario **(FIGURE 7)**. As one student put it, "The most helpful aspect of the virtual autopsy simulation was the interactive 3D models," while another appreciated how "everything was explained" in a way that connected the theory to practice. Together, these features allowed students to immerse themselves in realistic scenarios, making the simulation an effective tool for understanding complex forensic concepts.

FIGURE 7 A screenshot of one of the bodies from the virtual autopsy. This particular body was found at a fire so the body is charred. In the screenshot, students selected loopers for the autopsy.

The simulation's usability and organization received mixed feedback. While 60% of respondents agreed that the interface was user-friendly, 40% noted that the saving process and interface were not as intuitive as they would have liked. However, 80% of respondents agreed that the six-week simulation was well-structured and effectively organized, while 20% disagreed. Some students mentioned that additional tutorials and hints would help improve navigation and accessibility during the simulation. These results highlight the simulation's ability to provide a realistic and structured learning experience while also pointing to areas for improvement in usability and support.

Impact on Student Performance:

The use of the simulation positively impacted student performance. An analysis of final grades revealed that all students in the course passed, with no grades falling below a B. Among the 10 students, six earned high Bs, and four achieved As. The capstone assessment, which accounted for 50% of the final grade, played a significant role in evaluating student mastery of forensic investigation skills.

Students were assessed on their performance and completion of the autopsy exercises through a combination of module tests, lecture materials, and hands-on simulation activities. During the simulation sessions, students were required to complete various forensic documentation forms—including autopsy reports, gunshot wound analysis sheets, and photo evidence logs—based on the evidence provided in each scenario. These completed forms were uploaded to the Learning Management System (LMS) and graded for completion and accuracy.

Additionally, the capstone assessment included seven mini-exams (the original exam and six scenario-based assessments) that tested students' ability to analyze forensic evidence and apply investigative principles.

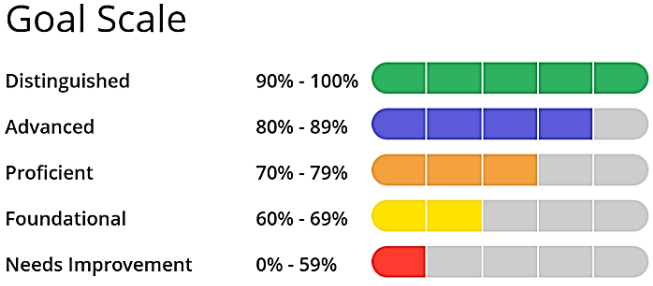

FIGURE 8 Goal scale for the Mastery Report

While the capstone also included a survey, the survey itself was not graded. By integrating theoretical knowledge with applied forensic tasks, the simulation-based approach ensured that students not only met learning objectives but also demonstrated strong performance across multiple assessment components

In addition to final grades, the Mastery Report in Blackboard Ultra was utilized to evaluate student performance across three key institutional learning outcomes: Analytical Reasoning, Critical Thinking, and Quantitative Literacy **(FIGURE 8)**. These outcomes emphasized critical and analytical thinking, the application of theoretical principles, and the ability to collect and interpret data through computational literacy and scientific reasoning. These outcomes were aligned and linked to the capstone, with Analytical Reasoning assessed through the scenario-based mini-exams, Critical Thinking evaluated through case assessments in the mini-scenario exams, and Quantitative Literacy measured in the original exam, where students analyzed forensic autopsy photos to identify wounds, cuts, and procedural techniques. These assessments were directly mapped within Blackboard Ultra, allowing the Mastery Report to track student progress and categorize their achievement levels (4,7).

The Mastery Report is a tool within Blackboard Ultra that tracks student achievement against specific learning goals (7). It aggregates data from assessments aligned with these goals, categorizing student performance into levels such as Distinguished, Advanced, Proficient, and others, based on predefined scoring ranges (4,7) **(FIGURE 9)**. Each aligned component, such as rubric criteria or test questions, contributes to these levels, offering a detailed view of how students are mastering the material (7).

For all three outcomes, the student results were categorized into the following levels:

- **Distinguished** (100–90%): 1 student
- **Advanced** (80–89%): 6 students
- **Proficient** (70–79%): 3 students

The distribution of scores shows that the majority of students achieved either advanced or distinguished levels, indicating a strong grasp of course content and its practical application. The Mastery Report provided valuable insights into how well students met these learning objectives by clearly outlining their progress. It highlighted areas of success and identified opportunities to refine instructional strategies for future courses.

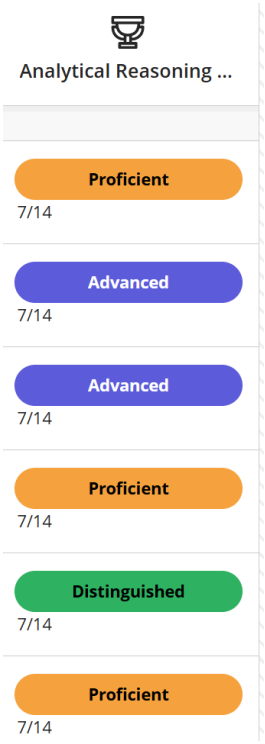

FIGURE 9 Screen shot of one of the alignment goals in the gradebook. Instructors can view how each student is performing against those alignments.

Discussion

By incorporating virtual autopsy simulations into the CRJU524 Death Investigation course, we overcame logistical challenges while enhancing student engagement and comprehension. Students found the realistic scenarios invaluable, as they bridged the gap between conceptual understanding and practical application. Survey responses revealed that the simulation sparked curiosity, boosted confidence, and sharpened critical thinking skills, underscoring the power of technology-driven tools in connecting classroom concepts to real-world practices.

While the use of simulation proved highly effective, some usability challenges were identified. Students reported difficulties with navigating the interface, saving progress, and adapting to the immersive environment, and a few experienced physical discomforts, such as dizziness. To address these concerns, students were provided with regular breaks, access to water, and the alternative option of viewing the autopsy via video. Although watching the video did not offer the fully immersive and interactive experience of the simulation, it allowed students to review the information at their own pace and pause as needed. This accommodation ensured that all students, regardless of their preferences or needs, could engage meaningfully with the course content.

While no students in this course required the use of a screen reader or had dexterity-related challenges that prevented the standard use of a mouse, accessibility considerations were considered. The co-author of this paper, who serves as the Senior Instructional and Digital Accessibility Specialist at Coppin, provided guidance on ensuring that the simulation remained inclusive.

Coppin State University's Learning Management System (LMS) is certified accessible by the National Federation for the Blind, ensuring compatibility with assistive technologies (8). Additionally, all surveys were conducted using Microsoft Forms, which is designed to be digitally accessible and works seamlessly with screen readers and other assistive tools. Within the capstone assessments, all images included in exams had alternative text added, allowing students using screen readers to access critical visual information.

The Autopsy Simulator included captions, which would have supported students with hearing impairments. If a student had required a screen reader, we would have supplemented the captions with an electronic transcript containing all scenario details to ensure equitable access to the content. Additionally, for students unable to use a standard mouse, the video-based alternative would have been a viable option, as the video player supports keyboard navigation, touch, and stylus input.

Since this was the pilot implementation of the Autopsy Simulator, these accommodations will be formally integrated as standard options for future course offerings. Furthermore, additional accommodations will be provided as needed to support individual student needs.

Students also indicated in their survey responses that they would appreciate being given more tutorials, real-time feedback, and optional hints for navigating around on the Autopsy Simulator. This would further reduce barriers and improve the user experience. Additionally, offering targeted support for students in the "Proficient" category could help close performance gaps. This support might include personalized feedback, more scaffolded assignments, and more time to redo the simulations and supplementary materials to reinforce analytical reasoning and critical thinking skills.

Expanding the simulation's use across disciplines, such as anatomy, health sciences, and criminal justice, could amplify its impact. Incorporating group-based collaborative features would mirror real-world teamwork and encourage peer learning. The capstone project, which required students to document their findings reinforced essential professional skills. This model could be adapted for other courses to integrate immersive learning tools with academic assessments, expanding the reach of this approach.

This study had several limitations that should be acknowledged. First, the small sample size of 10 students limits the generalizability of the findings. Additionally, the reliance on self-reported survey data introduces the potential for bias, as students may have overstated or understated their experiences. Also, as a pilot program, this was the first time the virtual autopsy simulator was integrated into the course, making it a pivot from the originally planned morgue visits, which were unavailable. This change eliminated the possibility of conducting pre-tests and post-tests to measure learning gains. Another limitation is the potential for instructor bias, as the authors of this paper were also the instructors of the course. While every effort was made to present objective findings, this dual role may have influenced the interpretation of results. These limitations highlight the need for further research with larger, more diverse populations and more structured evaluation methods such as pre-tests and post-tests to validate and build on these initial findings.

By addressing these challenges and building on its strengths, the simulation-based learning model holds great promise for enhancing education in a variety of fields. The insights gained from this study provide a foundation for refining and expanding its use, paving the way for more engaging and effective learning experiences.

Conclusion

The virtual autopsy simulation effectively engaged students, strengthened forensic skills, and offered a practical, immersive learning experience. By addressing logistical barriers and integrating innovative technology,

the program maintained academic rigor and prepared students for real-world forensic challenges.

While improvements in usability and accessibility are needed, positive student feedback and strong performance outcomes underscore the simulation's potential. As one participant noted, "This experience showed how virtual tools can combine interactivity and realism to improve understanding and engagement in complex subjects."

Moving forward, the authors are committed to refining the simulation based on feedback from its first implementation. Future updates will address usability concerns and better align the program with student needs. These enhancements aim to solidify the simulation as a key component of forensic education, ensuring students are well-prepared for the demands of professional practice.

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