ILLUMINATIONS | Curricular Integration of Physiology

Connecting anatomy and physiology concepts in an interdisciplinary high-fidelity patient simulation with undergraduate nursing and allied health students

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INTRODUCTION

A gap exists between concepts considered to be essential undergraduate curriculum: those that are taught, and those learned through nursing and other health professions. This divide can be narrowed by creating a new learning space (10) where students can explore the health professions early through collaborative experiential learning and self-inquiry.

Contextualizing basic sciences through application to clinical medicine has been an integration strategy implemented in medical curriculum as educators seek to optimize the transfer of basic science knowledge to the clinical realm (4, 6, 7). An integration strategy underutilized in basic science education is simulation-based experiences, despite its offering active, experiential student learning opportunities (12). Simulation’s growth potential across healthcare was envisioned by Gaba (5) through dimensions of simulation applications that included basic science education. Experiences using high-fidelity patient simulators can provide contextualization of fundamental basic science concepts, such as those learned in anatomy and physiology (A&P).

The integration of patient simulation-based experiences in A&P supports the Interprofessional Education Collaborative Expert Panel (9) core competencies of expanding beyond profession-specific education to interprofessional education. Furthermore, patient simulation-based experiences in A&P create a collaborative, guided opportunity for purposeful learning among students pursuing various nursing and health profession degrees in a new interprofessional learning space.

The purpose of this article is twofold: 1) to share qualitative data findings from a pilot study involving only undergraduate nursing students who participated in the simulation activity at a small, private college in the Midwest; and 2) to detail the curricular design of a simulation activity for undergraduate students in various allied health degree programs. The 90-min human patient simulation activity was part of a 200-level Human Anatomy and Physiology II laboratory course. At the time of the pilot study, the student population was composed only of undergraduate nursing majors; therefore, only undergraduate nursing student-participants’ learning experiences were documented in a postsimulation feedback and reflective essay assignment. The pilot study was approved by the Institutional Review Board (IRB) and the Human Research Review Board (HRRB), and informed consent was obtained from all pilot study participants.

After the pilot study ended, enrollment in the A&P II course shifted and began to include health science and radiography majors and college credit plus (CCP) students in subsequent semesters. Although the additional allied health majors and CCP students were not part of the pilot and were not in the IRB proposal, the simulation activity curriculum was modified to include these new students through an expansion of role assignments; however, no data were collected on these individuals. This was the initial introduction to simulation in an A&P course given to students at the college, as they were provided patient information on the human patient simulator (HPS) only in the A&P II course. The course consisted of laboratory activities and dissections with limited face-to-face lecture. All students were concurrently enrolled in the human anatomy and physiology II lecture course. The simulation activity was developed and facilitated by a nursing faculty member and biology faculty member at the college. The goals of this article were to 1) report pilot study findings on undergraduate nursing student-participants’ learning experiences, as documented in a postsimulation feedback and reflective essay assignment; and 2) determine the feasibility of integrating an interdisciplinary simulation activity into an A&P laboratory session.

Pilot Study

A total of nine undergraduate nursing students, age 18 yr and older, participated in the pilot as the A&P II course only enrolled nursing majors at the time of the pilot study. Participants were recruited to participate in the pilot research study by a faculty/staff member who did not teach A&P II. All pilot study participants provided informed consent to include their reflective essays in the study and were also interviewed after successfully completing the A&P II course and given a $20 coffee card for their participation, as approved by the HRRB. These nursing student participants’ reflective essays were analyzed and provided the qualitative data for this pilot study. All pilot study participants were undergraduate nursing students.
Case Study and Simulation Activity Design

As enrollment in the A&P II course changed, the simulation activity was revised after the pilot study ended to include role assignments that aligned with other majors and students who enrolled in the A&P II course. No data were collected or analyzed on the additional allied health and CCP students, as they were not in the pilot study or included in the IRB proposal. The simulation curriculum was modified as role assignments were expanded to include these new students and are reflected in the descriptions below. Depending on the semester, the number of nursing and allied health majors (e.g., health science or radiography) and CCP students varied. A typical A&P II laboratory course section enrollment was capped at 20 students, with ~75% nursing and 25% other majors. All assessment and intervention activities were done using one high-fidelity HPS (CAE iStan) at the college. An outline of the activities is depicted in Fig. 1 and described as follows.

Evolving case study. Students in the A&P II course were introduced to the patient early in the semester through an evolving case study scenario that addressed relevant hematological, cardiovascular, respiratory, and acid-base physiology concepts, as well as nonspecific defense mechanisms. The four-part evolving case study followed a patient as he was confronted with various health issues. Content (face) validity of the case study and simulation was established by a primary care physician/clinical assistant professor. Students were given the case study throughout weeks 3–10 in the 15-wk semester, with each component aligned and linked with an A&P and/or nursing student learning objective (SLO) (see the APPENDIX). The final case study component contained prebriefing assignments to prepare students for the simulation activity, where they physically cared for the case study patient they had been following all semester in the form of a high-fidelity HPS.

Prebriefing. One week before the simulation, the nursing and biology faculty members met to determine role assignments for the simulation based on the students’ progression in their various degree programs. The student prebriefing included a brief background of the patient simulator’s reasons for admission, a description of each student’s role assignment, and evaluation checklists for those serving as observers during the simulation. Nursing student roles portrayed in the simulation included a charge, medication, assessment, or documentation nurse. Health science students often served as laboratory value interpreters, as they researched laboratory data and educated their peers on potential etiologies of abnormal laboratory values. Radiography students were safety observers, documenting if safety protocols were followed, observing patient positioning, and noting any A&P concepts manifested by the high-fidelity HPS. CCP students often served in a family member role or were paired with a radiography or health science student to assist in interpreting laboratory values, observing safety practices, and/or noting A&P concepts. To maintain engagement throughout the simulation activity, students in the laboratory class collectively drafted their expectations for communication and conduct. The biology faculty member reminded students to be familiar with the case study components and their roles before the simulation activity.

Introduction (15 min). Before the start of the simulation, students were given a briefing on the capabilities of the patient simulator, medical supplies, and the physical setting of the room. A general approach to assessing and caring for the patient simulator and the logistics of the simulation activity were discussed. Four to seven students actively cared for the patient simulator, while four to seven students acted as family members or observed, monitored, and evaluated laboratory data, safety, communication, and concepts (A&P and nursing) during the simulation. Those in observer roles were informed that they would be instrumental in leading the debriefing session after the simulation.

Simulation part 1 (20 min). The first half of the simulation began with the nursing faculty providing a hand-off [Situation, Background, Assessment, Recommendation (SBAR)] report on the patient simulator who was in a motorcycle accident and subsequently admitted with a fractured right tibia and fibula, necessitating a closed-reduction surgery and cast application. Precursure nurse students assessed the patient simulator and provided nursing care. The nursing students initiated interventions, such as rest, ice, and elevation of the extremity to prevent swelling of the patient simulator’s leg. Ten minutes into the scenario, the patient simulator verbalized an increase in pain at the surgical site, while students noted physical manifestations of tachycardia, tachypnea, and a higher blood pressure reading. Nursing students consulted the chart for pain medication orders and had the option to consult the physician about the opioid dose
in a narcotic naive patient. Morphine was administered to the patient simulator at the conclusion of the first half of the simulation. Throughout the simulation, faculty members openly answered questions posed by students and prompted students to think about physiological concepts that were pertinent to the patient simulator’s condition.

**Debriefing of simulation part 1 (15 min).** A debriefing session occurred after the first half of the simulation. The biology faculty member prompted student discussion of various physiological concepts recorded by student observers and participants. Physiological reasons for interventions provided to the patient simulator were also rationalized during debriefing. Multiple paths were pursued as student discussions often centered on opioid receptors and the impact of an opioid overdose on the respiratory system, laboratory results and coagulation, inflammation, and the body’s nonspecific defense mechanisms. Further discussion focused on the impact of opioid overdose in relation to the physiology concepts of the oxyhemoglobin dissociation curve and respiratory acidosis. The first debriefing session concluded with observers and participants discussing team, patient, and family member communication.

**Simulation part 2 (20 min).** The second half of the simulation ensued with the patient simulator manifesting bradycardia, bradypnea, hypotension, and lower than normal pulse oximetry as a result of a morphine overdose. Students recognized the effects of the opioid overdose and called the physician who subsequently gave orders for the antidote, naloxone (Narcan), to be administered. After the administration of naloxone, students noted an immediate high level of pain being reported by the patient simulator, as well as elevated vital signs; additional orders were given by the physician for students to administer a pain medication. Upon a focused assessment of the right leg, students noted the toes on the right foot were cool to touch, cyanotic, and edematous. Students suspected the patient to have compartment syndrome and contacted the physician for orders, who subsequently ordered the cast to be bivalved and preparation to be done for a possible fasciotomy surgery. Throughout the simulation, faculty members prompted and posed questions to students, compelling them to critically think about physiology concepts that were pertinent to the patient simulator’s condition.

**Debriefing of simulation part 2 (20 min).** The final debriefing session included a discussion of the signs of compartment syndrome that resulted from complications of a closed-reduction surgery and cast application. The relationship of relevant concepts, such as perfusion and oxygenation, were discussed to promote understanding of the physical manifestations of compartment syndrome. Additionally, a visual display of swelling inside of a compartment, a plastic bottle with three different colored pipe cleaners to signify an artery (red), vein (blue), and nerve (tan), was displayed with a towel inserted into the bottle to demonstrate the increased internal pressure within the compartment, which resulted in compression on the vessels and nerves (pipe cleaners). A short fasciotomy video was shown to illustrate the surgical intervention done for acute compartment syndrome with infection being discussed as a risk factor for fasciotomies. A discussion was led by the nursing faculty on the importance of neurovascular assessment, interventions, positioning, safety, and the underlying A&P involved. The final debriefing session concluded by allowing observers and participants to discuss team, patient, and family member communication.

**Pilot study reflective essay.** In the pilot study, a postsimulation assignment was given to assess what concepts the nursing student-participants identified in the A&P II laboratory simulation activity. The purpose of the assignment was to determine nursing students’ level of comfort with the simulation and what was learned from the experience (Table 1).

### Table 1. Results of student reflective essay assignment analysis

| Areas                                      | Themes                                      | Student Learning Outcomes                                      |
|--------------------------------------------|---------------------------------------------|-----------------------------------------------------------------|
| A&P                                        | Treatment of inflammation with the rest, ice, compression, elevation (RICE) technique. Fractures involving the skeletal system anatomy. Respiratory system and the effects manifested by morphine. | Classify what regulates and causes inflammation (2).* Recognize the cardinal signs of inflammation (2)*. |
| Nursing components that merge with A&P     | Assessment, pain, and vital signs. Neurovascular assessment. Compartment syndrome. | Classify the causes and compensation for acid-base imbalances (respiratory and metabolic) (2).* Differentiate variables that shift the oxyhemoglobin dissociation curve (2).* “Demonstrate caring, safe, and competent nursing interventions in diverse healthcare settings” (3).* |
| Communication and confidence during simulation | Structural comforts through role assignments. Emotional barriers. Interpersonal communication as a team. Therapeutic communication with the patient and family. | “Incorporate a variety of communication modes for effective exchange of information” (3).* |

A&P, anatomy and physiology. Thematic analysis results are shown for the essay prompt, “Reflecting back to what you have learned in Anatomy and Physiology lecture and lab (I and II), what concepts stood out, if any, in this simulation experience? (Provide a minimum of a one-page personal, reflective essay response indicating if any A&P concepts stood out and, if not, what concepts you observed in the simulation).” *Student learning objectives were adapted from the A&P II master course syllabus (2). †Nursing student learning objectives are taken from Ref. 3.
pretest/posttest assessment to relate physiology concepts to the simulation activity. The pilot study included only undergraduate nursing students, age 18 yr and older, who were asked to voluntarily complete the reflective essay assignment and informed consent if they consented to participate in the pilot study. Nine of 14 students, eight women and one man, completed the assignment and the informed consent for the pilot study.

Each student was asked to rate his/her level of comfort with the simulation experience on a Likert scale from 1 to 6 (1 = very comfortable, 2 = comfortable, 3 = somewhat comfortable, 4 = somewhat uncomfortable, 5 = uncomfortable, and 6 = very uncomfortable). Participants were asked to describe and explain why they gave the simulation experience their rating. Qualitative data analysis was conducted on these responses and included in the communication and confidence results section below. One of the nine students did not rate her level of comfort. Among the eight respondents, 25% (n = 2) were very comfortable, 50% (n = 4) were comfortable, and 12.5% (n = 1) were somewhat comfortable, whereas only 12.5% (n = 1) were very uncomfortable.

Data analysis was conducted on the nine student reflective essay assignments in which students answered the prompt:

Reflecting back to what you have learned in Anatomy and Physiology lecture and lab (I and II), what concepts stood out, if any, in this simulation experience? (Provide a minimum of a one-page personal, reflective essay response indicating if any A&P concepts stood out and, if not, what concepts you observed in the simulation.)

Coding of the reflective essay data was conducted shortly after the data were collected, as it is recommended to interweave data analysis with data collection (8, 11). Words were assigned to segments of written text during the process of coding and condensed into analyzable sections. Coded text sections were arranged into related groups and compared and contrasted to identify patterns and generate concepts (8). Themes that emerged from analysis of the participants’ essays were related to three overarching areas: A&P, nursing, and communication and confidence during the simulation. Connections drawn between the HPS’ manifested physiological responses and nursing assessment components were not isolated and often interconnected, as illustrated by the study’s themes. These themes also align with several A&P and nursing SLOs linked in the original case study leading up to the simulation activity (see Table 1).

RESULTS AND DISCUSSION

This study demonstrated that, on a small scale, it is feasible to integrate an interdisciplinary simulation activity into an A&P II laboratory course and obtain a positive learning effect based on students’ identified A&P and nursing concepts from the activity and reported perceptions of comfort and communication.

Feasibility of Simulation in A&P

A difficult component of integrating this activity into an A&P II laboratory was scheduling the 90-min simulation at a time when the simulator was not in use. It was critical to use a simulation scenario that was not in the nursing curriculum at that time to ensure that the activity was a new learning experience for all involved. Therefore, the nursing faculty member/simulation coordinator chose compartment syndrome, as it integrates several A&P concepts into one scenario. The first three parts of the case study were written by the biology faculty member, with both nursing and biology faculty writing the last part leading up to the simulation. A significant investment in time and collaboration was made by both faculty members before implementing the case study and simulation activity in the course.

Faculty members provided more information and direction on role assignments, the patient’s condition, and the logistics of a simulation than what is provided in a typical nursing simulation clinical experience. For example, two debriefing sessions were integrated into the simulation to allow students time to discuss, during the first debriefing, the physiological ramifications on different body systems after administering an opioid overdose and, in the second debriefing, issues of compartment syndrome and interventions (i.e., assessment, positioning, and safety). Students were prepared to care for the patient simulator as student roles were assigned based on previous course work and experiences with simulation.

Identified Concepts of the Activity and SLOs of Case Study

Foremost A&P concepts emerged from the essay analysis and were correlated with SLOs. Seven of nine essays explicitly mentioned the rest, ice, compression, and elevation (RICE) technique and its physiological ramifications, with three participants detailing the impact of RICE on venous return. The classification of fractures and the skeletal system were also discussed in one-third of the essay responses, as students recalled the bones and type of fractures that the patient sustained in the simulation. Over one-half of the essay respondents (n = 5) discussed the effects of morphine on the respiratory system, as one student noted the relationship between respiratory rate, carbon dioxide, hydrogen ion, and pH levels. One particular student reflected on how she and her classmates “went from being concerned about the broken leg and pain as nurses, to how lethargic and hard it was to get the patient to talk and respond to us.” The connection drawn being the patient’s physiology and nursing assessment were often intertwined with other concepts, as one participant highlighted this connection in seeing “the physiological concepts of what we learn in the patient setting.”

Nursing concepts that were discussed by respondents could also be linked to a nursing SLO from the case study. Four respondents mentioned assessment, pain, and vital signs, with some noting the impact of pain on vital signs, particularly after giving the opioid antidote, naloxone, to the patient. Neurovascular assessment was also highlighted by two of the participants, as one student noted that “assessing blood flow and nerve status is an essential part of a nursing assessment.” Compartment syndrome was a concept discussed by three respondents who recalled the visual demonstration and fasciotomy video shown during the second debriefing session. A nursing student who cared for the patient simulator reiterated that one must have “an accurate understanding of A&P to perform a head-to-toe assessment. . . [which is] one of the most important tasks that a RN can do.”
Comfort and Communication During Simulation

Among the eight respondents, 87.5% (n = 7) self-reported some level of overall comfort after the simulation activity. Analysis of the responses revealed that one-third of the respondents (n = 3) indicated the role assignments given during prebriefing alleviated some anxiety with the simulation activity, as one participant stated that she “appreciated knowing what role I would be assigned in advance so that I knew what the expectations of me were.” Prebriefing provided role assignments and detailed information about the patient before the simulation; however, students were somewhat uneasy and insecure with working in front of their peers as a student commented that she “still need[ed] to work on . . . [her] confidence in the clinical setting.”

Communication is critical in any educational or healthcare environment and was mentioned explicitly in over one-half of the participants’ reflections. The biology and nursing faculty members were intentional in maintaining positive and open communication by including two debriefing sessions. The nursing faculty indicated that “debriefing occurred at different points in the scenario so students know throughout the scenario that they are on track with their thinking and judgments.” Open communication was encouraged throughout the simulation and was found to be reassuring, as a student noted that she “felt more comfortable because everyone was there to help [and] we could ask questions.” Therapeutic communication with the patient and family was also recognized as important by students in the simulation as one individual indicated that “family members and their recognition of changes in patient status . . . [were] extremely helpful in identifying problems early” in the simulation. Communication was recognized as an important element of the simulation activity, as a participant stated that it allowed her and her classmates to “work as a team and be hands on with different people.”

Data revealed that participants did identify both A&P and nursing learning outcomes relevant to the case study and simulation exercise. Students viewed the simulation activity favorably, as one student wrote that the experience was positive because “we as students were put into a situation that challenged our knowledge and provided us a chance to problem solve—as opposed to just going through the motions of an activity.”

Overall, the authors recognize generalizability as a limitation of this pilot study, as research was conducted in the context of a small, private college setting and included a small sample size. The challenge of conducting this simulation activity with a large group of students is contingent on institutional access to high-fidelity patient simulators, faculty facilitators, and streaming capabilities. With access to the necessary technologies, it is possible that a group of 25–30 students could be assigned to each simulator, along with a biology and nursing faculty facilitator present. The introduction might be expanded to orient students to the patient simulator by dividing the large group into two smaller groups and orienting each small group of 12–15 students at a time, with the other group observing via live streaming in a separate classroom. The first small group could assume the described roles during simulation part 1 and its debriefing, while the other small group observes via live streaming in a classroom. After the debriefing of simulation part 1, the small groups would switch, allowing the second small group an opportunity to assume the roles and engage in simulation part 2 and its debriefing, while the other group observed through live streaming in the classroom. At a large university, which may have a simulation center housing three or four high-fidelity patient simulators, it is possible that a large lecture section of 100–120 students could implement the simulation activity in smaller groups concurrently, with ample classroom space, faculty facilitators, and streaming capabilities. The reflective essay assignment requires minimal grading, as its purpose is to have students summarize and analyze their experiences.

Table A1. Evolving case study timeline

| Timeline | Case Study Details | A&P SLOs (2)* | Nursing SLOs (3)† |
|---------|--------------------|--------------|------------------|
| Week 3  | Patient’s complete blood count results provided; abnormalities researched for physiological basis. | ● Summarize blood’s components and functions. | “Provide nursing care within the legal and ethical scope and standards of nursing practice.” |
| Week 5  | Patient’s family history investigated as related to cardiovascular issues, risk factors, and medications. | ● Outline a homeostatic imbalance of the blood. | “Demonstrate caring, safe, and competent nursing interventions in diverse healthcare settings.” |
| Week 9  | Completion of nursing prebriefing assignment for patient simulation experience of fractured tibia and fibula, including nursing interventions and postsurgical risk factors for closed-reduction surgery with cast application. | ● Identify a normal cardiac cycle, cardiac output, and the heart’s electrical and contractile activity. | “Incorporate a variety of communication modes for effective exchange of information.” |
| Week 10 | Completion of A&P prebriefing assignment for patient simulation covering oxygenation as related to opioid narcotic impact and physiological rationale for RICE (rest, ice, compression, elevation). | ● Recall factors impacting blood flow. | “Demonstrate caring, safe, and competent nursing interventions in diverse health care settings.” |

A&P, anatomy and physiology; SLO, student learning objectives. *Student learning objectives were adapted from the A&P II master course syllabus (2). †Nursing student learning objectives are taken from Ref. 3.

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evaluate concepts recalled from the simulation experience and is an extension of the minute paper classroom assessment technique described by Angelo and Cross (1). Modifications to the reflective essay might entail specific requirements and an associated grading rubric to facilitate more structured grading of the assignment. However, the intent of the assignment in this study was to allow students an open space to reflect on perceived concepts in the simulation activity.

Future studies are recommended where the pilot results are used as a guide for the development of an assessment and a pretest-posttest quantitative study on the impact of using simulation in an A&P course. Implementing simulation in an A&P II laboratory course, an application that transects several of Gaba’s (5) simulation dimensions, provided an opportunity to contextualize the relevancy of A&P to the nursing and health science professions while engaging students from different degree programs in a common experiential activity.

APPENDIX

A weekly timeline and summary of each evolving case study component and its alignment to the A&P and/or nursing student learning outcomes is provided in Table A1.

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The Division of General Education has changed names and become part of the Division of Foundational Education and Health Professions since the time that the pilot study was conducted. The authors have since vacated their positions at Aultman College of Nursing and Health Sciences in Canton, Ohio. J. M. Hillyer is currently a doctoral candidate at Kent State University and Kathleen Gordon is now retired.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

J.M.H. and K.A.G. conceived and designed research; J.M.H. and K.A.G. performed experiments; J.M.H. analyzed data; J.M.H. interpreted results of experiments; J.M.H. and K.A.G. prepared figures; J.M.H. and K.A.G. drafted manuscript; J.M.H. and K.A.G. edited and revised manuscript; J.M.H. and K.A.G. approved final version of manuscript.

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