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# Using High-fidelity Medical Simulation to Assess Critical Thinking in Medical Students

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ABSTRACT


USING HIGH-FIDELITY MEDICAL SIMULATION TO ASSESS

CRITICAL THINKING IN MEDICAL STUDENTS




by

Lynda Daniel-Underwood


Chair: Robson Marinho

ABSTRACT OF GRADUATE STUDENT RESEARCH

Dissertation


Andrews University

School of Education



Title:   USING HIGH-FIDELITY MEDICAL SIMULATION TO ASSESS
         CRITICAL THINKING IN MEDICAL STUDENTS

Name of researcher: Lynda Daniel-Underwood

Name and degree of faculty chair: Robson Marinho, Ph.D.

Date completed: February 2016

### Problem

Graduating competent physicians is an imperative societal need. The development of critical thinking skills during medical school is important to meet this societal need and for the care of ill patients. Research shows this skill is key in decreasing medical errors, which in turn decreases cost. (Norman and Eva, 2010) Missing from the literature is a method to assess critical thinking in the setting of caring for the critically ill patient. This instrumental case study tests medical simulation as a method of assessing critical thinking, which incorporates all six competency domains, by looking at the assessment environment, summative patient experience, and participant's reflection on the case and environment.

Method

A qualitative instrumental case study design was used to evaluate twelve senior medical students' critical thinking skills in the setting of identified competency domains. A single simulation patient encounter was administered to each student and data collected from the videotape of the encounter, their written documentation, and oral presentation of the case, mimicking the real-life scenario. The participants were also asked five questions regarding this case. These data were analyzed and presented in narrative format.

Results

The analysis revealed six major themes: assessment environment, coalescence of knowledge and skills, decision-making and deep thinking/reasoning, integrative experience, lack of depth in thought process, and safe environment.

This research identified gaps in the students' knowledge, skill, and behaviors of competency domains as they apply to critical thinking. Despite all students successfully completing medical school, errors were made in their individual care of the simulated patient. Four cases ended in "death" of the patient. The documentation of their patient encounter also lacked sufficient detail to allow other medical professionals to understand the issues during the case.

The students' opinion of the patient encounter was positive. Several students noted they had not had similar encounters as the sole provider of patient care. The experience gave them the opportunity to apply what they had learned and reflect on their gaps in knowledge.

Conclusions

The ability for physicians to think critically is key in reducing medical errors. An effective instrument to assess critical thinking as it applies to competency is high-fidelity medical simulation. In addition, allowing senior medical students to manage the case as the physician in charge exposes knowledge, skills, and behaviors of critical thinking, making these processes accessible for assessment.

Andrews University

School of Education

USING HIGH-FIDELITY MEDICAL SIMULATION TO ASSESS

CRITICAL THINKING IN MEDICAL STUDENTS

A Dissertation

Presented in Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

Lynda Daniel-Underwood

February 2016

USING HIGH-FIDELITY MEDICAL SIMULATION TO ASSESS

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APPROVAL BY THE COMMITTEE:

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Member: Shirley Freed

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External: Loretta Johns                                    Date approved

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INTRODUCTION

Between 44,000 to 98,000 patients die each year as result of medical errors. The estimated cost of these errors is $19.5 billion, with surgical errors costing $1.5 billion (Poillon, 2000). It is not without reason that interest in patient safety has been growing in the United States. Patient safety as defined by the National Patient Safety Foundation (NPSF, 2015) is "the prevention of health care errors, and the elimination or mitigation of patient injury caused by health care errors." Norman and Eva (2010) describe medical errors as being multifactorial. They state that analytical problems arise from cognitive or processing biases, which can be attributed to the large majority of errors. The clinician assumes the most likely cause of the problem but fails to focus on another etiology, which could prove to be life-threatening. The clinician does not gather more data, or pursue additional information. The lacking analytical process is known as critical thinking.

The definition of critical thinking was formed from a distillation of thoughts from 46 experts in varying fields by critical-thinking expert P. Facione (1990) in the executive summary of the Delphi Report. Their definition states critical thinking as a "process of purposeful, self-regulatory judgment" (p. 2). Norman (2005) narrowed the definition for medical education to "complex and multidimensional components of knowledge and skills used to solve patient problems to achieve effective care" (p. 426).

**Background of the Problem**

In my medical education from 1987 to 1994, critical thinking was not taught or assessed formally, but rather modeled and assessed by probing questions about diagnostic decisions from the teacher. However, in the last 10 years, medical teaching has expanded to include assessing the learner's cognitive process. Courses have been created to aid in the transition from knowledge acquisition to interpreting clinical findings with basic science (K. Anderson, Peterson, Tonkin, & Cleary, 2008; Jacobson, Fisher, Hoffman, & Tsoulas, 2010; Van Gessel, Nendaz, Vermeulen, Junod, & Vu, 2003). In 2012, the Liaison Committee on Medical Education (LCME) released its new accrediting requirements for medical schools, which allow "medical students to acquire skills of critical judgment based on evidence and experience" (p. 7). In 1999, the Accreditation Council for Graduate Medical Education (ACGME, 2013) defined six domains of competency that each residency must meet. These six domains of competencies are patient care, medical knowledge, professionalism, interpersonal and communication skills, systems-based practice, and practice-based learning and improvement.

Englander et al. (2013) defines these competencies. In patient care learners are to "provide patient-centered care that is compassionate, appropriate, and effective for the treatment of health problems and the promotion of health" (p. 4). Students demonstrate medical knowledge of "established and evolving biomedical, clinical, epidemiological and social-behavioral sciences, as well as the application of this knowledge to patient care" (p. 4). Professionalism is shown by a "commitment to carrying out professional responsibilities and an adherence to ethical principles" (p. 5). Learners demonstrate skill in interpersonal and communication skills by having "effective exchange of information

and collaboration with patients, their families, and health professionals" (Englander et al., 2013, p. 4). Systems-based practice is an "awareness of and responsiveness to the larger context and system of health care, as well as the ability to call effective on their resources in the system to provide optimal health care" (p. 5). Practice-based learning and improvement is one's ability "to investigate and evaluate one's care of patients, to appraise and assimilate scientific evidence, and to continuously improve patient care based on constant self-evaluation and life-long learning" (p. 4).

Each clinical rotation addresses these domains and therefore, is the same for each learner, although the teacher and the patient vary. One learner may have limited supervision or observation time with the evaluator or the patient selection is limited because of variation in the types of illness. This provides for inconsistency and bias in the assessment of the student's ability to think critically.

High-fidelity medical simulation is defined as "providing the trainee with the cues necessary to suspend their disbelief during dynamic, immersive, hands-on scenarios. They offer mannequins that react in realistic ways to trainees' interventions" (Yeager et al., 2004, p. 328). In medical education, high-fidelity medical simulation is used to teach high risk skills. Simulation allows for integration of knowledge and skill without endangering patients or models. It mimics real scenarios more closely by providing a patient (high-fidelity mannequin) and an environment that closely approximates a hospital's various patient care areas. Can simulation be an effective assessment tool for high-risk skills and cognitive processing in medical students?

New medical school graduates (physicians) are placed in clinical situations that affect patients' lives and their safety. A Loma Linda University (LLU) School of

Medicine graduate is required to possess cognitive process skills in critical thinking to recognize degrees of illness severity (LLU, 2013). LLU uses the Association of American Colleges and Universities' definition of critical thinking as "a habit of mind characterized by the comprehensive exploration of issues, ideas, artifacts and events before accepting or formulating an opinion or conclusion" (n.d.).

Currently, high-fidelity medical simulation is being used for teaching, but underutilized as an assessment tool in undergraduate medical education. This problem was recently reinforced by Fero et al. (2010) who noted, "No studies were identified in which the relationship between traditional measures of critical thinking and simulation-based performance was explored" (p. 2189). Gordon, Wilkerson, Shaffer, and Armstrong (2001) recognized "students were stimulated by thinking through real problems under the pressure of a realistic simulation" (p. 472). They also found "that high-fidelity patient simulation may be a powerful new tool to bridge basic and clinical science, foster critical thinking, and enhance retention" (p. 472).

## Problem Statement

Scalese, Obeso, and Issenberg (2007) state clinical situations require abilities in all six competency domains expected by the ACGME. These six domains of competencies are patient care, medical knowledge, professionalism, interpersonal and communication skills, systems-based practice, and practice-based learning and improvement (ACGME, 2013). Although formal assessments to test each domain exist, simulation may be ideal in bringing all six domains into one assessment tool. Critical thinking is a skill that is necessary in bridging all six domains because it requires knowledge of disease, interpersonal skills and communication, navigation through the

medical system, and self-regulation for professional growth. High-fidelity medical simulation is a powerful teaching tool; therefore, the problem addressed in this research is to explore how medical simulation utilizing high-fidelity mannequins can serve as an effective method to assess critical thinking.

## Purpose of the Study

The purpose of this study is to analyze how high-fidelity medical simulation performs as a tool for assessing critical thinking skills in senior medical students.

## Research Questions

The overarching research question to be answered is: How is high-fidelity medical simulation an effective assessment tool for critical thinking in senior medical students? This overarching question is addressed by three specific questions:

1. In what ways does medical simulation provide an assessment environment similar to an actual patient encounter where critical thinking is crucial for patient safety?

2. In what ways does the senior simulation case provide a summative patient experience for assessing critical thinking competency for beginning post-graduate-year 1 (PG-Y1)?

3. What was the student's thought sequence that led to the differential diagnosis, final impression, disposition, and their perception of the simulation?

## Rationale for the Study

The justification for this study is based on the need in medical education for an assessment tool for critical thinking that bridges the six competency domains.

**Theoretical Framework**

The theoretical framework for this study is based on the Dreyfus and Dreyfus (1980) model of skill acquisition. They described a five-stage model for skill acquisition. Each stage is described with certain attributes (skill, behaviors, and knowledge) and each stage is dependent on completion of the stage before. This model is currently used as the basis for competency assessment by the ACGME (Sullivan, Simpson, Cooney, & Beresin 2013).

The first stage is the novice. Novices are learning the process, protocols, procedures, language, and culture (of medicine). Their behaviors are rule-governed (learning heuristics) and respond to external reward systems. They need supervision and have little or limited problem solving skills.

Stage 2 is the advanced beginner. Based on the description of skills and behaviors, medical students completing their education would possess most of these skills. These learners recognize common situational aspects in their patient cases that are not apparent apart from the experience. Their behavior is still rule-governed, but their heuristics skills are better developed as is their concept learning. They still require supervision.

Stage 3 is described as competence. They see their actions in terms of goals and plans based on some of the important aspects of the situation. They depend on standard procedures as a base of consideration, but can modify the plan if necessary. They need supervision and case discussion for problem solving, which adds accountability.

Stage 4 is the proficient physician. All physicians completing residency should be at this level. They streamline procedures unconsciously and are proficient in managing

conflicting medical situations and in adjusting to the cultural factors. They need minimal supervision and continue to evolve their critical thinking skills.

Stage 5 is the expert. Expert physicians perform intuitively in synthesizing medical, cultural, and psychological influences into fluid, flexible, and efficient care plans. They respond to external stimuli, which may be obscure to the less skilled and profoundly obvious to the expert. They require no supervision and are self-regulated in their learning. The expert is considered unconsciously competent.

As the physician develops from the novice (medical student) to the expert (practicing physician), critical thinking skills are refined to include efficient problem-solving, requiring no supervision, responding to stimuli which may seem obscure to the less skilled, and performing intuitively in synthesizing medical, cultural, and psychological influences.

In addition, Bloom (1956) developed taxonomy for educational objectives. His work to classify statements of learner expectations (educational objectives), was conceived as a way to facilitate exchange of test questions, measuring the same educational objective. With the aid of a group of measurement specialists, six categories were developed. Their cognitive domain categories were ordered from simple to complex and concrete to abstract. These categories were from lowest to highest, Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. An assumption made is the simpler category was a prerequisite for the next more complex one. When it was initially introduced the word "taxonomy" was unfamiliar in education and as the potential for education assessment framework was see, its value increased and today is widely known.

The original Taxonomy, he believed could serve as a common language, determine a particular meaning for a course or curriculum along a continuum, and determine congruence of assessments and objectives.

The knowledge category involves recognition or recall of information. Comprehension involves the translation, interpretation, or extrapolation of information. Application is linking knowledge to the problem. Analysis of relationship, elements and principles was the next level followed by synthesis. Synthesis included production of unique communication, plan, or abstract relations. The understanding and use of knowledge were classified from comprehension to synthesis. The last category was evaluation; judgments of internal evidence or external criteria.

Krathwohl (2002) revised Bloom's Taxonomy to reflect a two-dimensional framework: knowledge and cognitive processes. For Krathwohl, knowledge is subdivided into four dimensions: factual, conceptual, procedural, and metacognitive. He defines factual as "basic elements that students must know to be acquainted with a discipline to solve problems in it" (p. 214). Conceptual is "interrelationships among the basic elements within a larger structure that enable them to function together" (p. 214). Procedural knowledge is embedded in skills, techniques, and criteria to answer "how to do something." Metacognitive knowledge is "awareness of and knowledge about one's own cognition" (p. 214). He renamed Bloom's Knowledge category to Remember. His revised categories are: Remember, Understand, Apply, Analyze, Evaluate, and Create. He defines Remember as "retrieving relevant knowledge from long-term memory" (Krathwohl, 2002, p. 214). Understand is "determining the meaning of instructional messages including oral, written, and graphic communication" (p. 214).

Apply is "carrying out or using a procedure in a given situation" (p. 214). Analyze is "breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose" (p. 214). Evaluate is "making judgements based on criteria and standards" (p. 214). Lastly, Create is "putting elements together to form a novel, coherent whole or make an original product" (p. 214). Table 1 is a modified summary of Krathwohl's revisions of Bloom's Taxonomy.

Table 1

*Summary of Krathwohl's Revision*

| Knowledge Dimension | Cognitive Dimension | | | | | |
|---|---|---|---|---|---|---|
| | Remember | Understand | Apply | Analyze | Evaluate | Create |
| Factual Knowledge | | | | | | |
| Conceptual Knowledge | | | | | | |
| Procedural Knowledge | | | | | | |
| Metacognitive Knowledge | | | | | | |

Bloom's hierarchical approach to educational objectives serves as the framework for developing critical thinking skills from the perspective of course assessment. Assessment tools, for example tests, essay discussion, or rubrics, developed for evaluation of individual performance within the course, are based on this order.

## Significance of Study

Simulation may be a better method of assessing critical thinking. It allows the student to be immersed in the case as one would be in the real patient care environment. This study helps to clarify the use of high-fidelity medical simulation as a tool to assess critical thinking.

## Definition of Terms

The following are definitions to clarify key terms used in this dissertation:

*ACGME.* Accreditation Council for Graduate Medical Education. A

private professional organization responsible for the accreditation of about 9,200
residency education programs. Residency education is the period of clinical
education in a medical specialty that follows graduation from medical school, and
prepares physicians for the independent practice of medicine. (ACGME, 2013)

*Assessment.* Measurement of capabilities of learners "providing motivation and direction for future learning" (Epstein, 2007, p. 388).

*Critical thinking.* "Purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based" (P. Facione, 1990, p. 2). "Complex and multidimensional components of knowledge and skills used to solve patient problems to achieve effective care" (Norman, 2005, p. 426).

*High-fidelity medical simulation.* "Provid[ing] the trainee with the cues necessary to suspend their disbelief during dynamic, immersive, hands-on scenarios. They offer mannequins that react in realistic ways to trainees' interventions" (Yeager et al., 2004, p. 328).

*LCME*. Liaison Committee for Medical Education (Epstein, 2007).

Medical education programs leading to the M.D. degree in the United States and Canada are accredited by the Liaison Committee on Medical Education (LCME). The LCME's scope is limited to complete and independent medical education programs whose students are geographically located in the United States or Canada for their education and that are operated by universities or medical schools chartered in the United States or Canada. (LCME, 2013)

*Medical error*. "Injuries caused by medical management" (Kohn, Corrigan, & Donaldson, 2000, p. 210).

*Patient safety*. "Freedom from accidental injury due to medical care or error" (Kohn et al., 2000, p. 155).

*PG-Y*. Post-graduate year. The number following this designates the year in training of the resident (ACGME), e.g., post-graduate year-1 is a resident in the first year of training.

*Resident physician*. Physician who attained the MD degree, but is still in training. The term is used interchangeably in this study with "resident" (ACGME, 2013).

## Basic Assumptions

There are three basic assumptions for this study. The first basic assumption is that high-fidelity medical simulation is a superior tool for assessment due to its approximation of an actual patient care encounter. The second assumption is that medical education provides students a learning environment that addresses critical thinking. The last assumption is the senior year is the appropriate time to complete the assessment.

## General Methodology

This study is based on qualitative research design using the case study methodology, that is, a study bounded or described by certain parameters. An

instrumental case study was used to answer the research questions. Stake (1995) states, "The instrumental case study is research on a case to gain understanding of something else" not the case itself (p. 171). He defines instrumental case as "accomplishing something other than understanding this particular [case]" (p. 3).

Using high-fidelity medical simulation as an assessment tool, allows the immersion of the learner in a true to life patient encounter. The reason for a qualitative study for this research is that it enables the researcher to observe a certain event which includes several facets in a specific environment (Bogdan & Bilkin, 2003). Since the case requires the learner to describe the story of the patient and their own care of the patient in that moment in time, it is appropriate for qualitative methods to be used for such experiences (Patton, 2001).

Creswell (1998) describes five traditional methods of qualitative research. One of these, the case study, makes meaning of the actions or interactions that take place when people are placed in certain situations, and it examines the process in which they assign meaning to their experiences (Bogdan & Bilkin, 2003). Case study is suitable for this research because it applies the same single patient encounter to assess several learners' individual experiences.

With the help of the Associate Dean for Clinical Education and the Senior Associate Dean for Education, a purposeful sampling of the senior medical school class was obtained. The students in the senior class were ranked by class standing and divided into quartiles. Although Creswell (2013) recommends a sample of four or five participants for a single case study, 12 participants were solicited for this study which was representative of the quartiles. An email was sent to the senior class describing the

study and requesting participants. The selected participants were ranked by class standing. The ranking was done to assure selected participants represented all quartiles. I was not aware of the class ranking of the 12 participants, until all participants completed the case.

Each participant/medical student completed the simulation and then wrote up the simulated patient's medical history and his or her findings from the physical examination. The student also discussed his or her medical decision-making process, the diagnosis, and finally the plan of action. Then the participant made an oral presentation of the case to a faculty physician. After the presentation, two questions were asked of the student: "What were your thought sequences that led to the differential diagnosis, final impression, and disposition?" and "What were your perceptions of the simulation session?" The entire simulation session including the oral presentation and questioning was videotaped and the answer to these questions transcribed.

To assure the validity of my findings, the method of triangulation was utilized. Experienced physician educators from the Loma Linda School of Medicine scored the written and oral presentations using the same rubric. The evaluator derived a consensus from the disagreements or differences from the review of the scores.

### Limitations

The following are the limitations of the study:

1. Participants could discuss the simulation case with each other after completion.

2. Restriction to a single medical school. Although the curricula content for all medical schools is standard, the presentation of the material varies.

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3. Although the simulation room and mannequin mimic the real-life area in sounds and equipment, the mannequin provides no visual cues.

4. Behavior: Behavior of one person may not always reflect that of another.

5. Students participating in the study were applying for Emergency Medicine.

## Delimitations

This study is delimited to completion at only one medical school with a small sampling of senior medical students completing the same simulation case. The case selected for the participants was a septic patient, but results could vary with selection of a trauma case versus non-critically ill patient.

## Summary

This study aims to determine if high-fidelity medical simulation is an effective tool to assess critical thinking in senior medical students. The inability of students to recognize and process critical information can lead to patient injury, delay of care, inaccurate diagnosis and ineffective treatment plans. Medical simulation offers the opportunity for medical students to display their decision-making process, to integrate knowledge and expertise to solve patient problems, and hence to achieve safe and effective patient care. The ability of medical schools to determine the level of the student's capacity to think critically can allow for intervention prior to unsupervised patient encounters as they progress to the first year of post-graduate training.

CHAPTER 2

LITERATURE REVIEW

After an extensive review of the literature, three areas of importance emerged: critical thinking, assessment in medical education, and high-fidelity simulation. The relevance of these areas are addressed in the context of patient safety.

Resources and databases used to identify reports, books, experts in the field, and peer-reviewed articles were Andrews Dissertations, Dissertation Abstracts, EBSCO, JSTOR, PubMed, ERIC, Google Scholar, Loma Linda University Office of Educational Effectiveness, ACGME, AAMC, Institute of Medicine, Department of Health and Human Services web resources, and personal communication with experts in patient safety and medical education assessment. Key words used to conduct this review were *critical thinking, medical assessment, assessment, novice to expert, patient safety, problem based learning, script concordance testing, clinical reasoning, medical simulation, and simulation.* In medical education research, there are overlapping concepts or interchangeable terms related to critical thinking. These keywords were also researched: *analytic reasoning, problem solving, decision making, clinical/diagnostic reasoning/ judgment, habits of mind, meta-cognition, and adaptive expertise* (Krupat, 2008).

**Critical Thinking**

This section addresses the definition of critical thinking and the development of critical thinking skills in medical students. Peter Facione (1990) defined critical thinking

as the "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based" (p. 2). Norman (2005) defined critical thinking in medical education as "complex and multidimensional components of knowledge and skills used to solve patient problems to achieve effective care" (p. 426).

In a study conducted by Krupat et al. (2011), 97 clinical-educators from five medical schools were surveyed regarding their definition of critical thinking and their application to clinical practice. Three distinct descriptions of critical thinking were found. The most frequent definition ($n$=42) framed critical thinking as a process of linking complex patient information to an appropriate treatment plan. The second most frequent definition ($n$=40) was that it is a skill or ability that enables a physician to collect data, determine missing information, or render appropriate actions. The third description framed critical thinking as individual traits ($n$=14), which includes one's own observation of the clinical encounter and identification of the patient's unique situation.

When critical thinking is defined as a process, this leads one to consider the steps needed to determine treatment plans. When critical thinking is defined as a skill or ability, it indicates that critical thinking may be taught or learned as a set of heuristics. The implication from the third definition is that critical thinking is part of one's habit of mind and personality, engenders curiosity but can be limited by one's personal biases.

The Liaison Committee for Medical Education (LCME) is the accrediting body for medical schools in Canada and the United States. It addresses the requirement of medical schools to both teach critical thinking skills and assess their development.

Standard ED-6 states that the curriculum must "allow medical students to acquire skills of critical judgment based on evidence and experience; and develop medical students' ability to use principles and skills wisely in solving problems of health and disease" (Liaison Committe on Medical Education, 2012, p. 7). The LCME in Standard ED-28 requires "ongoing assessment of medical students' problem solving, clinical reasoning, decision making, and communication skills" (p. 12).

For the purpose of this study a synoptic definition of critical thinking using the above definitions has been constructed: critical thinking is a complex process of skill or ability, integrating knowledge and expertise to solve patient problems and achieve safe and effective patient care.

**Development of Physician Skills**

There are two primary methodologies used in medical education to develop students' critical thinking skills: experiential and heuristics learning. Experiential learning described by Kolb and Kolb (2005) is a compilation of the works of John Dewey, Kurt Lewin, Jean Piaget, William James, and others as a "holistic model of the learning process and a multilinear model of adult development" (p. 194). There are six fundamental principles that are the basis of experiential learning: Learning is a process; all learning is relearning; learning involves conflict resolution; learning is a holistic process of adaptation to the world; learning is a synergetic process involving the learner and the situation; and it is a process of creating knowledge. From this, one can gather that learning is an active process and involves several regions of the brain. In his study evaluating simulation as a method of learning, Kolb describes the case as providing "the realistic patient environment" (Kolb, 1984, p. 154). The case provides this learning space

Kolb describes to achieve the fundamentals of experiential learning.

Educators should ensure that events are designed to encourage the learner in ways that offer them opportunity to engage in the style that suits them best. Also, individual learners can be helped to gain knowledge more effectively by the recognition of their lesser preferred learning styles and the support of these through the application of the experiential learning cycle (McLeod, 2010).

Kolb and Kolb (2005) defined a four-stage learning cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Each stage is tied to experience and change in behavior. In concrete experience, the learner asks why and behavior is based on feeling. Contrasted to this is the abstract conceptualization. At this stage the learner is thinking about the experience and asking how. In reflective observation, the learner is watching the experience and is deciding what to do. Contrasted to that is active experimentation in which the learner is engaged in the experience and is contemplating various aspects of the experience.

The learning styles Kolb and Kolb (2005) describe are based on the Learning Style Inventory created in 1985. Learning stages and cycles could be used by a teacher to evaluate the learning conditions typically available to students and to develop more appropriate learning opportunities. There are four learning styles:

1. Diverging (feeling and watching) in which the learner is between concrete experience and reflective observation

2. Assimilating (think and watch) which is between the reflective observation and abstract conceptualization

3.   Converging (think and do) which is between the abstract conceptualization and active experimentation, and

4.   Accommodating (feel and do) which is between the active experimentation and concrete experience (Kolb & Kolb, 2005).

Armstrong and Parsa-Parsi (2005) stated that a learner should be able to use the four stages to gain the most effective learning from each experience.

In the clinical sciences of medical education, the medical students learn from their experiences in patient encounters. These encounters can allow the student to observe, feel, do (complete a physical examination or procedure), and reflect cultural, racial, or social aspects of the patient in the context of their own attitudes.

McNeil, Hughes, Toohey, and Dowton (2006) describe using adult learning theories to construct a medical education program which included "learning from experience" (p. 527). They link developing knowledge structures to reflection, as the best use of the experience. In medical education, the development of critical thinking skills is accomplished by providing clinical experience to even the novice learner through case-based learning, team-based learning, problem-based learning, and simulation. Case-based learning, team-based learning, and problem-based learning are learner-centered methods, whereby the learner obtains and utilizes knowledge and skills in solving problems and establishing their own learning goals (Barrows & Wee Keng Neo, 2007). Team-based learning provides interchange and discussion within teams and between teams to help teach judgment, which Parmelee (2008) feels to be the foundation of rigorous clinical reasoning. These methods are primarily used in the first two years of medical education.

The last two years of medical education, students learn in a supervised environment with living patients.

Another methodology employed is heuristics. The Liaison Committe on Medical Education (2012) describes this as using "rules of thumb" (p. 206) to problem solve. Rules of thumb are steps or algorithms taken to create an appropriate solution to the problem. Bransford and Stein (1984) described a heuristic method, IDEAL. The steps guide the learner to identify the problem, define and represent the problem, explore solution strategies, act on the strategies (trial and error), and look back and evaluate the effects of the activities (reflection).

Teaching interpretation of electrocardiograms (ECG) is an example of heuristics in medical education. Norman, Brooks, Colle, and Hatala (1999) in their study describe two groups of participants. The first group developed a diagnosis of the clinical problem found in the ECG using data and rules given to them (accuracy 41.9%). The second group of participants was asked to make the diagnosis and then provide supporting evidence. The second group was found to be more accurate in diagnosis (61.3%). In the basic sciences, heuristics is used in the identification of disease processes such as acute coronary syndrome, which includes myocardial infarctions (heart attacks). Students are taught the list of clinical features which they match to make the correct diagnosis. In the clinical years, they continue to use these rules in making a diagnosis; but the differential diagnosis is broadened by the breadth of experience.

In order to facilitate learning critical thinking in medical courses, faculty developed learning objectives based on Bloom's taxonomy (Plack et al., 2007). Bloom (1956) described a classification system for cognitive, skills, and behavioral learning

objectives. This has been known as Bloom's taxonomy or the revised Bloom's taxonomy (L. Anderson & Krathwohl, 2001). The higher-order objectives are considered to show critical thinking skills (Larkin & Burton, 2008). Each successive level builds until the learner reaches the higher order, which for the cognitive domain is evaluation. The affective domain is characterized by a value or a value concept, and the psycho-motor domain is characterized by naturalization.

Carraccio (2008) describes the medical student as at novice, based on Dreyfus and the Dreyfus Model. She describes the Novice as "rule driven, use[s] analytic reasoning and rules to link cause and effect, and has little ability to prioritize information, so synthesis is difficult at best and the big picture is elusive." (p. 176)

As medical students progress into physicians, development of their knowledge, skills, attitudes, and behavior is best described by Dreyfus and Dreyfus Model and Bloom's Taxonomy where critical thinking is crucial at each step.

**High-Fidelity Medical Simulation**

This study examines critical thinking in the context of utilizing high-fidelity simulation as an assessment tool. The term high-fidelity simulation is used to describe the mannequin's behavior and appearance to mimic the simulated (real) encounter (Issenberg et al., 1999). Gaba (2004) defined simulation in healthcare as "a technique—not a technology—to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner" (p. 12).

Historical Development of Simulation in Medical Education

Simulation began with the idea of placing people in high-stake situations without

the risk of the loss of lives. Edwin Link pioneered the use of a flight trainer because he felt there was an easier, safer, and less expensive way to learn how to fly (as cited in Rolfe & Staples, 1986). After a devastating accident in 1934, the military purchased a Link trainer to improve their pilot training. Their needs increased during World War II and they purchased more Link trainers for world-wide use. The addition of analog and digital computers improved flight modeling. National Aeronautics and Space Administration (NASA) collaborated with Link to develop systems that further improved the trainer. NASA has used the simulator extensively in training ground and flight crews. In 1955, the Federal Aviation Administration required simulation for commercial pilot's recertification. With the introduction of passenger flights in aircraft like the Boeing 707, planes flew higher and experienced clear-air turbulence, which could be violent at times causing severe handling problems. Simulated learning became even more critical. The simulators were developed to mimic the same violent turbulence experienced by pilots in flight. Pilots trained under these simulated conditions resulted in marked change in the crew's performance in the Boeing 707 (Rolfe & Staples, 1986).

The development of medical simulation followed a similar evolution from its initial singular use to today's sophisticated use in high-stake procedures and patient encounters. In 1958, Laerdal began research and development for bystander resuscitation (Rosen, 2008). In 1960 "Resusci Annie" was born. She was used to provide training in chest compression. In 1968, "Harvey" was created as a cardiology patient simulator. The concept of Harvey continued to be developed to include sense interventions completed by the learner. The American Heart Association in subsequent years used both Resusci Annie and Harvey to demonstrate and assess competence in bystander cardiopulmonary

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resuscitation and advanced cardiac life-support (ACLS).

In 1988 Piemme showed that computer-assisted learning and evaluation was a value (Rosen, 2008). Prior to this date, other resources for evaluation were being developed. In 1973 patient encounter simulation was developed which became the prototype for the computerized examinations for the National Board of Medical Examiners (NBME). In 1995, the Anesoft Corporation developed the Anesthesia Simulator 2.0, ACLS Simulator 3.0, and Critical Care Simulator. This led to other companies developing the technology further by adding PC-based simulations. "SimMan" was created by Laerdal in 2000. This was the path to today's current high-fidelity simulator mannequins (Rosen, 2008).

Simulation as an Assessment Tool

With the advent "Resusci Annie" and subsequent development of high-fidelity simulators, simulation has become the primary method of teaching in situations of high-risk of mortality and morbidity and low-frequency procedures or skills. Federal and private insurance plans, shorter admission stays for various diseases, a new emphasis on outpatient management and minimally invasive procedures, and federally mandated restriction on work hours for residents have affected medical education (Dawson, 2006). The impact is that residents and medical students are evaluating fewer patients, completing fewer procedures, and thus learning less.

Dawson concludes that our traditional system of education is perhaps outdated. He recommends that simulation is "well-suited for rehearsing elements of a procedure that may be unfamiliar or infrequently performed" (p. 207). He suggests several additional roles for simulation in medicine including aptitude testing, early skills

acquisition, advanced skills training, career-long training, board examination, credentialing, procedural training, and replacement of animal laboratories.

Simulation creates a "real time" environment for learning. Nackman, Bermann, and Hammond (2003) compared simulation to case-based learning. The fourth-year students at the start of the clerkship had case-based learning of shock. The simulation was offered mid-way through the year. Fifty-four students completed the simulation sessions. Both groups completed an OSCE. They found OSCE scores significantly improved in the simulation group in all three cases of shock. They also learned the cause-and-effect relationship between management choices by the critical decisions and errors they made.

Medical students are usually left out of primary management of acutely ill patients, yet upon graduation, they immediately experience the anxiety of caring for severely ill patients. Gordon et al. (2001) offered simulation sessions to all third- and fourth-year medical students completing their emergency medicine rotation. Twenty-seven students participated. Students were given two simulation cases: one case where the patient was critically ill and the second the patient was moderately ill. In a follow-up survey of multiple choice and open-ended questions, students reported in the interview critical thinking and active learning being fostered during the sessions. They also indicated it improved their procedural skills in a safe environment.

In a randomized, double-blinded study of 16 surgery residents, Seymour et al. (2002) divided them into two groups. One group was assigned to the operating room to complete gallbladder surgery. The second group was assigned to simulation prior to the operating room for gallbladder surgery. They first completed a baseline psychomotor assessment of all residents, which showed no difference between the two groups. Surgical

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simulation improved operating room performance.

Simulation allows students to learn in a safe environment the life-saving skills that are infrequently performed, but also allows them a "real-time" interaction with the "patient" to improve clinical skills and critical thinking. In addition simulation improves performance of technically challenging procedures.

Simulation has been used as a training tool in medical education since the early 1960s, but it has been gradually transitioning to an assessment tool as well (Devitt, Kurrek, Cohen, & Cleave-Hogg, 2001). The ACGME (2000) created a toolbox of assessment methods with brief descriptions of each method for resident performance outcomes. Simulation was one of 13 assessment tools suggested. Each method was matched to required skills and competency. They then classified each method for the required skill as "most desirable," "next best method," or "potentially applicable method." ACGME recommends simulation for assessment in multiple domains. It lists simulation as the "most desirable" method of assessing medical procedures, and the "next best method" for development and carrying out patient management plans, investigatory and analytical thinking, knowledge and application of basic sciences, and ethically sound practice.

Rogers (2004) states evidence supports the use of simulation as a superior evaluation tool. He recognized that it allows the teacher ability to evaluate cognition and motor skills in real time. Swing (2002) described simulation as the best method of assessment for certain cases described as "low-frequency but important situations where there is high risk to the patient" (p. 1285). In a 10-year review of the 128 medical schools in the United States and Canada, simulation was listed as a pedagogical tool in 92% of

the schools. In review of the individual medical schools' assessment tools, simulation as assessment is still lacking to the extent it is used for learning (M. Anderson & Kanter, 2010).

Miller (1990) developed a pyramid as a framework of levels of performance in clinical assessment. In increasing importance, these levels are: knowledge, competence, performance, and action. Miller felt that "no single assessment method can provide all the data required" (p. S63) for a physician to perform successfully. But Scalese et al. (2007) noted that simulations are most appropriate for trainees to show competence in a variety of skills and competency domains. Scalese et al. (2007) affirmed simulators show a high degree of reliability, consistency, and minimized variability. On behalf of the Society for Academic Emergency Medicine Simulation Task Force, W. Bond et al. (2007) found that simulation "re-creates the 'experience' of patient care" (p. 354). They also noted that computer screen-based simulations lack fidelity and environmental cues that immerse the learner into the case, unlike a real patient encounter.

Khan, Pattison, and Sherwood (2011) also state "recall of information and its application are best when it is taught and rehearsed in environments similar to [the] workplace" (p. 1). They further describe healthcare profession as "heavily task- and performance-based" where decision-making and clinical reasoning are key (p. 1). Most attributes related to professionalism, such as integrity and empathy, are difficult to assess in traditional classrooms.

Boulet et al. (2003) noted that a key goal of healthcare education should be the development of teaching and evaluation tools that measure performance in settings that reflect clinical practice. They noted that standardized patients and written tests do not

mimic critical care events. Hence, high-fidelity simulation provides this setting.

Murray et al. (2007) tested anesthesia participants with intraoperative simulation exercises and found that simulation-based assessment was a method, which provided a valid venue to distinguish the skills of anesthesia residents in early training from that of more experienced residents and anesthesiologists. In another study Murray et al. (2005) found that simulation-based assessment was valuable in identifying deficits in skill achievement during training. Marcario (2014) describes using simulation as an assessment tool for physician performance as defined by the ACGME competency domains. Deering (2013) utilized simulation for medical student, resident and fellow education in obstetrics.

**Assessment of Critical Thinking in Medical Education**

This section reviews current methods and research in assessment in critical thinking in medical education. The ACGME in 2000 developed a model of domains of competence: medical knowledge, patient care, professionalism, communication and interpersonal skills, practice-based learning and improvement, and systems-based practice. The ACGME has defined competencies with these domains for graduate medical education, but medical schools are gradually transitioning to similar domains. Epstein (2007) stated:

> Assessment plays an integral role in helping physicians identify and respond to their own learning needs. Ideally, the assessment of competence (what the student or physician is able to do) should provide insight into actual performance (what he or she does habitually when not observed), as well as the capacity to adapt to change, find and generate new knowledge, and improve overall performance. (p. 387)

Measurement Tools of Critical Thinking in Medical Education

Epstein (2007) describes commonly used methods of assessment in medical education. They include written exercises, assessment by supervising physicians, clinical simulations, and multisource assessments. The four most prominent tools for assessment for critical thinking are script concordance testing, objective structured clinical examinations, direct observation, and high-fidelity simulation.

**Script Concordance Testing**

Script concordance testing (SCT) was developed as an assessment method to evaluate the degree of concordance between the learner's conclusions and a panel of experts on a written test problem (Charlin, Roy, Brailovsky, Goulet, & Van der Vleuten, 2000). The first step in the SCT testing process is the development of a multiple-choice test based on a clinical vignette. This is administered to a panel of experts and each item choice is weighted according to the responses of the panel members. The learner's choice is also scored in accordance with weights assigned by the panel of experts.

Lubarsky, Chalk, Kazitani, Gagnon, and Charlin (2009) created and administered the SCT to multiple learners of varying levels of training. Their study revealed differences from the novice (medical students) to expert (PGY-5). They concluded SCT was an effective method to assess judgment. Humbert et al. (2011) developed an SCT in four basic science courses and administered it to 411 second-year students and 70 fourth-year students. They found that SCT differentiated between the two student groups and the panel of experts in their accuracy of problem solving skills. The higher the level of expertise, the higher the accuracy.

Fournier, Demeester, and Charlin (2008) developed SCT looking at data

interpretation as a key skill needed for clinical reasoning. In their study, they found

concordance between accurate data interpretation and clinical reasoning quality.

SCT has utility in testing many students at one time and distinguishing between

levels of learners' critical thinking skills. It is currently being used for national licensing

of physicians (Epstein, 2007).

**Objective Structured Clinical Evaluation**

The objective structured clinical evaluation (OSCE) to assess clinical skills was

introduced in 1979 by Harden and Gleeson in Scotland. This form of assessment allows

for the student to prove the breadth and depth of knowledge, but also allows them to

demonstrate professional attitudes and behavior (Shumway & Harden, 2003). This highly

choreographed, interactive examination combines reality of live clinical contacts, the

standardization of problems or patients, and the use of multiple observations of each

student (Hodges, Regehr, McNaughton, Tiberius, & Hanson, 1999).

Actors are trained to play clinical scenarios and an examiner or the standardized

patient scores the performance of the learners as they complete the scenario. Generally a

videotape is made and the learner completes a self-assessment within the context of

expert feedback. The OSCE lacks the opportunity to showcase learners' procedural skills

in real-time. Learners cannot perform procedures on the actor "patient" due to safety.

**Direct Observation**

In direct observation, the evaluator supervises the actual interaction between the

learner and the real patient. Epstein (2007) found the strength of direct observation in its

assessment of communication and clinical skills. Another strength is providing

immediate feedback to the learner, but the disadvantage is time involved in the process. Fromme, Karani, and Downing (2009) reviewed 53 articles that addressed observation and assessment. They found a difference between how a learner performs in a "simulated" situation where the learner demonstrating how to do the skill versus with actual patients, where the learning is doing the skill.

Medical students differ from residents in their level of expertise. Pulito, Donnelly, Plymale, and Mentzer, Jr. (2006) studied direct observation by collecting data from interviews as well as review of written faculty comments on third-year students. They found that faculty primarily observed cognitive skills and professionalism but clinical reasoning or judgment was not frequently observed. They also found that "history and physical examination, basic clinical skills, ordering of lab/diagnostic tests, technical skills, basic clinical skills, and interpersonal skills with patients" (p. 104) were seldom observed.

Howley and Wilson (2004) conducted a survey of third-year students from 1999-2001 in a single medical school, across all clerkships, asking if they had been observed by either a resident or faculty or if at all. They found that depending on the clerkship direct observation of a full examination ranged from 70-90%, but observation of history-taking was poorer, 26-74%. Direct observation can be time consuming and inconsistently applied to all students.

All four methods of assessment of critical thinking can show the stage of skill development (novice to expert). SCT is more useful for detecting differences in fund of knowledge between the novice and expert. Since this is a written test, it cannot assess procedural skill and does not evoke emotional responses to critical conditions. OSCEs

can be used for evaluating communication and focused physical examination skills. The learner also can be required, during an OSCE, to document the history and physical examination, which is the written communication skill. It cannot evaluate procedural skills or the process of thinking.

Direct observation can allow for evaluation of procedural skills, but when a novice is asked to complete a high-risk procedure on a real patient, patient safety becomes a prime issue. It is also time consuming for faculty to complete the entire observation. Simulation is costly and also condenses physiologic response times that do not mimic real-life, but it does allow the learner to be immersed in a "real-life" situation. It can assess communication, physical examination, written, and procedural skills, including high-risk procedures, without harm to the patient. This evaluation tool has the potential to assess the process of critical thinking; therefore, it requires further investigation.

<div align="center">Competency for Medical School Graduates</div>

**Liaison Committee for Medical Education**

Kassebaum (1992) describes the development of the LCME. It was established in 1942 as a result of the entry of the United States into World War II. The American Medical Association (AMA) and the American Association Medical Colleges (AAMC) provided oversight of medical education in differing ways. The AMA had the Council on Medical Education and Hospitals (CMEH) whose role it was to inspect and approve medical schools and inspect hospitals and approve them for internships. The AAMC evaluated medical schools for compliance with standards they set for membership. With changes made to the Selection Service Act in 1940, which created new obligations in

1942, the AAMC was asked by the Selective Service administration to advise on all matters related to medical education.

The AMA recognized the increased role of the AAMC in education. During this joint meeting in 1942, a liaison committee was created between the two organizations. In time, the Liaison Committee for Medical Education would be the name for the credentialing body for medical education for schools in Canada and the United States.

As part of the Medical School Objectives Project, Association of American Medical Colleges (1998) reported learning objectives for medical student education. The consensus group developed attributes medical students should possess upon graduation and set forth learning objectives based on the attributes. The attributes present upon graduation are: altruistic, knowledgeable, skillful, and dutiful. Under skillful, the "ability to reason deductively in solving clinical problems" (p. 7) is listed.

In *Functions and Structure of a Medical School* (LCME, 2012), standards for accreditation of medical education programs leading to the M.D. degree are listed. In Standard ED-26 the LCME requires "a system in place for assessment of medical student achievement throughout the program that employs a variety of measures of knowledge, skills, behaviors, and attitudes" (p. 11). ED-27 states there must be "ongoing assessment activities that ensure that medical students have acquired and can demonstrate on direct observation the core clinical skills, behaviors, and attitudes that have been specified in the program's educational objectives" (p. 11). The LCME requires that the student have the skills, behaviors, attitudes, and ability to solve problems commonly encountered in medical practice. No competencies are identified by the LCME.

In 2014, the LCME updated its standards. Standard 7, element 7.4 still requires

"the faculty of a medical school ensure that the medical curriculum incorporates the

fundamental principles of medicine, provides the opportunities for medical students to

acquire skills of critical judgment based on evidence and experience, and develops

medical students' ability to use those principles and skills effectively in solving problems

of health and disease" (LCME, 2014, p. 15). Standard 8, element 8.4 states

> a medical school collects and uses a variety of outcome data, including national
> norms of accomplishment, to demonstrate the extent to which medical students
> are achieving medical education program objectives and to enhance medical
> education program quality. These data are collected during program enrollment
> and after program completion. (LCME, 2014, p. 17)

Whitcomb (2004) made the plea for the LCME to require competencies since the

competency construct is defined across the continuum of graduate and continuing

medical education. Once students complete their undergraduate medical education, they

enter graduate medical education with defined competencies defined by the ACGME (M.

Bond, 2010; Sullivan et al., 2013).

The next assessment steps in the evaluation tools for medical education are the

Entrustable Professional Activities (EPAs). Ten Cate (2013) states, "EPAs are not an

alternative for competencies, but a means to translate competencies into clinical practice.

Competencies are descriptors of physicians; EPAs are descriptors of work" (p. 157). In

another article ten Cate states, "The EPAs—tasks or responsibilities that can be entrusted

to a trainee once sufficient, specific competence is reached to allow for unsupervised

execution—are not being defined in health care domains" (p. 7).

AAMC (2014) defines EPAs as "units of professional practice, defined as tasks or

responsibilities that trainees are entrusted to perform unsupervised once they have

attained sufficient specific competence" (p. 4). Thirteen defined EPAs have been

identified. Each EPA encompasses several competencies. Although not yet implemented in undergraduate medical education as assessments, they are being vetted.

The vision of the AAMC is to have these activities assessed in every medical student at accredited medical schools. It is to assure all graduating medical students have the same baseline skills upon starting residency. Many medical schools are already in the process of developing competency-based assessment tools, with milestones. The EPAs are designed to incorporate the milestones.

The EPAs are:

1. Gather a history and perform a physical examination.

2. Prioritize a differential diagnosis following a clinical encounter.

3. Recommend and interpret common diagnostic and screening tests.

4. Enter and discuss orders and prescriptions.

5. Document a clinical encounter in the patient record.

6. Provide an oral presentation of a clinical encounter.

7. Form clinical questions and retrieve evidence to advance patient care.

8. Give or receive a patient handover to transition care responsibility.

9. Collaborate as a member of an interprofessional team.

10. Recognize a patient requiring urgent or emergent care and initiate evaluation and management.

11. Obtain informed consent for tests and/or procedures.

12. Perform general procedures of a physician.

13. Identify system failures and contribute to a culture of safety and improvement (AAMC, 2014, p 1).

Robert Englander (personal communication, April 7, 2013) stated critical thinking encompasses all 13 EPAs. He remarked it is similar to critical thinking in complex tasks, where it encompasses all competency domains. Holmbe, Sherbino, Long, Swing, and Frank (2010) recommend "new assessment tools and approaches" be developed to "realize the promise of competency-based medical education" (p. 676).

The Affordable Care Act (ACA), signed into law in 2010 and implemented in 2013, instituted the meaningful use of electronic medical records (EMR); the changes within the billing system implemented by the Centers for Medicare and Medicaid Services (n.d.) have posed an interesting issue for written documentation. Only certain aspects of the student documentation may be used to formulate a patient note for billing. This affects completion of EPAs by medical students.

**Accreditation Council for Graduate Medical Education (ACGME)**

Most physicians in the 1800s were trained through apprenticeships and many did not attend medical school. Medical education was standardized through a series of events, like the creation of the AMA in 1847 and the AAMC in 1876. The ACGME grew out of the public need that specialists were indeed qualified to provide care. This led to the creation of medical specialties like surgery, medicine, and obstetrics with a board who oversaw the certification (Taradejna, 2007).

With the approval of Medicare in 1965, a graduate medical education need for coordination and quality assurance in residency programs arose. Various residency review committees joined to form the Coordinating Council on Medical Education in 1972. This eventually led to the creation of the Accrediting Council for Graduate Medical Education in 1981 whose responsibility would be to accredit graduate medical education.

In 2002, the ACGME identified and endorsed six general competencies. The American Board of Medical Specialties also endorsed the same competencies for continuing medical education.

The six areas or domains are patient care, medical knowledge, practice based learning and improvement, interpersonal and communication skills, professionalism, and systems-based learning (M. Bond, 2010). Carroll and Messenger (2008) recognized the change from objectives, which they describe as structure- or process-based education, to competencies was a paradigm shift. The measurement tools and evaluation processes are currently being established for each domain (ACGME, 2000). Englander et al. (2013) further developed a common language to describe the skills under each domain that lead to competence. These they felt would be universal for any healthcare profession. A key rule of competency-based education is that proficiency progresses on a continuum with each domain. Dreyfus and Dreyfus' (1980) 5-level model of acquisition of expertise has been used as a benchmark for residency evaluation from PGY1 through all years of training. Each specialty has developed skills for graduating medical students to possess at the novice level (Sullivan et al., 2013).

**Patient Safety**

The NPSF defined patient safety as "the avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from the process of health care" (Kohn et al., 2000, p. 57). The Institute of Medicine describes four types of errors. A diagnostic error is an error or delay in diagnosis, failure to order indicated tests, use of obsolete tests or therapy, or failure to act or follow up on results of monitoring or testing. Treatment error occurs when there is an error in the performance of an operation, procedure, or test, error

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in administration of treatment, dosing or administration method of medications, avoidable delay in treatment or in responding to an abnormal result, and inappropriate care. Preventive errors are described as failure to provide prophylactic treatment, inadequate monitoring, or follow-up treatment. The fourth class of errors is classified as other. They include failure to communicate, failure of equipment or other systems. About 70% of errors are thought to be preventable.

<div align="center">Error Prevention</div>

Medicine is unique as it relates to trainees. Most fields allow trainees to practice their craft before being allowed to work unsupervised. Errors made in the medical field can have significant consequences, supervised or unsupervised. Wachter (2012) states that diagnostic errors seem to represent human failings in cognition, but key in patient safety are the training and skills of the diagnostician.

**Analytical Versus Non-analytic Errors**

Errors occur primarily from two way of processing information. Non-analytical processing is unconscious match to previous knowledge, stored memory. Analytical processing is measured, calculated, logical, and theoretical whose application is to rules of diagnosis.

In a review of literature on clinical reasoning and psychology of dual-process models, Norman and Eva (2010) found that diagnostic errors are not simply a result of cognitive biases. Several attributes, which may lead to non-analytical errors, are attitude (lack of self-awareness), cognitive skills (processing bias), and knowledge deficits.

Bornstein and Emler (2001) conducted similar research and noted that physicians

are vulnerable to a number of biases. They posited three steps for making a clinical diagnosis: gathering evidence, interpreting the evidence, and probability assessment. Once the diagnosis is made a treatment plan is determined. Errors can occur either as a diagnostic bias or treatment bias.

**Learning Without Harm**

Wachter (2012) suggested a solution to error prevention is in the training environment. He suggested the environment should be one where the patients are protected from the trainees, although the result would be poorly trained clinicians who lack real experience. As the learner progresses from novice to expert, supervision decreases and autonomy increases. Wachter notes that supervisors in medicine have erred on the side of autonomy, giving the opportunity for the learner to learn while doing giving rise to the cliché "see one, do one, teach one" (p. 305). He suggests that rather than autonomy, oversight should be the role of the supervising physician.

Harasym, Tsai, and Hematti (2008) describe healthcare as "fallible" and "prone to diagnostic and management errors" (p. 341). They state about one-third of patient complaints are mismanaged because of diagnostic errors. They recommend as a solution improving physician critical thinking skills as they advance from medical school through residency.

Teaching patient safety in medical schools was suggested by the Lucian Leape Institute (2010), which suggested 12 additional recommendations for improving patient safety education, which included: the selection process for admission to medical school, the LCME to modify accreditation standards to the ACGME competencies, creating a culture to value patient safety, collaboration, team work, and financial or academic

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incentives. Dysinger and Pappas (2011) describe a fourth-year medical-student rotation

which is population-based in which students participate in a project dealing with

assessment, planning, implementation, and evaluation of an improvement project. The

students are placed in teams of three to four students. The theme of the projects can deal

with quality improvement or patient safety. With the movement in patient safety,

Wachter (2012) notes learning on patients is unethical when there are safer, practical

alternatives. He suggests simulation as a method to teach patient safety.

Simulation allows learners the occasion to learn and practice critical, time

sensitive skills without danger to patient or the learner. It can also offer time for

supervised review by an expert physician and reflection by the learner (McLaughlin et

al., 2008).

In their descriptive paper, Salas, Wilson, Burke, and Priest (2005) note one of the

most widely documented uses of simulation is anesthesia crisis resource management

training. These teams use simulation scenarios followed by detailed debriefing of their

performance. They also note that simulation can train surgeons on technical skills and

dexterity in the operating room and for expert surgeons to learn new skills.

In a policy paper, Ziv, Wolpe, Small, and Glick (2006) stated simulation-based

medical education "has the potential to decrease the numbers and effects of medical

errors, to facilitate open exchange in training situations, to enhance patient safety, and to

decrease the reliance on vulnerable patients for training" (p. 255).

Clinical Effects of Medical Error

Prevention of delay of care, efficacious treatment plans, and accurate diagnosis

are three areas which affect patients adversely. These result from the faulty clinical reasoning or critical thinking.

In their position paper, McNutt, Abrams, and Aron (2002) described a case of patient death due to delay in care. The case they describe is a patient who was to be admitted from the emergency department (ED) to the intensive care unit (ICU). The delay resulted from several factors: the inability of the ICU team to write computerized admission orders in the ED, a lag in transferring ED chart information to the inpatient chart, and the inability to contact the insurance company. They noted in reviewing this case, the adverse event occurred due to failure in decision-making. A poor decision by the physician to delay admission orders due to the lack of patient information in the computer and the execution of the poor decision by the physician not taking the initiative to complete hand-written orders to stabilize the patient contributed to the demise.

Many patient diagnoses are difficult to make because patients' history may not be the classic "textbook" description of the disease. Wachter (2012) describes the experience a physician acquires over years of practice that helps decrease the risk of errors. He goes on to say that too often without a systematic approach, clinical decisions are based on faulty reasoning which can be traced to poor training. He goes on to say "preventing errors is likely to depend on understanding how physicians approach diagnostic decisions, and providing them with tools (either cognitive or adjunctive, such as information technology) to help them make correct decisions more often" (p. 97). Errors in determining patient treatment plan can be the result of an analytical error i.e. incorrect interpretation of laboratory data, radiograph finding, or lack of recognition of an abnormal finding.

**Summary**

Medical education integrates knowledge, skills, behaviors, and attitudes in developing students' ability to care for patients. Assessment is a fundamental process to assure that learning has occurred, but it is key in determining gaps in knowledge as the learner progresses from a novice to expert. Assessment tools used in medical education should be able to evaluate all four content areas. Of the four assessment tools discussed, high-fidelity simulation appears to be the best tool to integrate all four areas. Simulation can evaluate knowledge, competence in procedural skills, communication, and immerse the learner in a realistic environment. Failure to recognize lapse in knowledge or skill can lead to potentially fatal errors for patients. Development and utilization of an assessment tool that can identify learners with deficiencies can save lives. Simulation is the best tool to assess the learners' ability to integrate knowledge and expertise to solve patient problems and achieve safe and effective patient care, critical thinking.

The LCME requires medical schools to develop critical thinking skills in medical students and to assess their skill acquisition. To complete this assessment without compromising patient safety is difficulty. This literature review reveals a gap in research evaluating high-fidelity medical simulation as an assessment tool to provide summative assessment of critical thinking in medical students in a competency-based education program. This study will answer that issue.

CHAPTER 3

METHODOLOGY

## Introduction

The purpose of this study is to analyze how high-fidelity medical simulation performs as a tool for assessing critical thinking skills in senior medical students. The overarching research question to be answered is: How is high-fidelity medical simulation an effective assessment tool for critical thinking in senior medical students? This overarching question is addressed by three specific questions:

1.   In what ways does medical simulation provide an assessment environment similar to an actual patient encounter where critical thinking is crucial for patient safety?

2.   In what ways does the senior simulation case provide a summative patient experience for assessing critical thinking competency for beginning post-graduate year 1?

3.   What was the student's thought sequence that led to the differential diagnosis, final impression, disposition, and his or her perceptions of the simulation?

## Qualitative Methods Design

The reason for conducting this qualitative research is because "a problem or issue needs to be explored" (Creswell, 2013, p. 47). The problem for investigation in this study is to analyze how high-fidelity medical simulation performs as a tool for assessing critical thinking skills. Merriam (1998) describes qualitative research as an "umbrella concept covering several forms of inquiry" about an issue (Merriam, 1998, p. 5). He goes on to

describe education as a "process and school is a lived experience" (Merriam, 1998, p. 4). Understanding the "meaning of the process or experience" is the strength of qualitative research (p. 4). To him, qualitative inquiry is inductive rather than deductive as in quantitative inquiry. Inductive inquiry uses examples to reach a general conclusion (Merriam-Webster Dictionary, 2015). In using participants experience to answer the research question, qualitative inquiry was chosen.

Creswell (2013) describes five arms of qualitative research as phenomenology, grounded theory, ethnography, narrative (biography), and case study. This study was conducted as a case study. He defined features of a case study to be bounded or described by certain parameters. To answer the above research questions, an instrumental case study was used. Stake (1995) states, the instrumental case study focuses on an "issue or concern" and then selects one "bounded case" which he described as "theta" to illustrate this issue or "iota" (p. 16). This case can be described as the simulation scenario being used to study the issue of critical thinking.

The case study makes meaning of the actions or interactions that take place when people are placed in certain situations, and it examines the process in which they assign meaning to their experiences (Bogdan & Bilkin, 2003). Case study is suitable for this research because it applies the same single patient encounter to assess several learners' individual experiences.

## Purposeful Sampling

With the help of the Associate Dean for Clinical Education and the Senior Associate Dean for Education, a purposeful criterion sampling of the senior medical school class was obtained. A purposeful sampling is described by Patton (2001) as

samples where researchers can learn about central issues. Schatzman and Strauss (1973) state the researcher selects people consistent to the purposes of the study. Creswell (2013) describes criterion sampling as "all cases that meet some criterion" (p. 119).

All participants were senior medical students. An email was sent to the senior class and participants were selected in sequence from the students who responded to this email. Fifteen students responded, but the first 12 were selected to participate. The Associate Dean for Clinical Education reviewed this list to assure the sample represented high and low student clinical performance, representing each quartile. They were consented and entered into the study. (See Appendix A for the consent form.) This was a purposeful sample, since all students were senior medical students at Loma Linda University, School of Medicine.

To be designated a senior medical student at Loma Linda University, a student must successfully complete two years of foundational science courses and the following clinical courses: Medicine, Pediatrics, Obstetrics and Gynecology, Surgery, Psychiatry, Neurology, and Family Medicine and pass the Step 1 examination for the United States Medical Licensing Examination (USMLE). Participants Allan, Bailey, and Caden were in the latter portion of the senior year.

## Data Collection

Creswell (2013) notes that in a case study, the researcher pursues "in-depth data collection involving multiple sources of information" (p. 97). He continues to describe these sources of information as participant observations, interviews, audiovisual materials, and documents and reports. Data was collected from written notes, videotaped simulation session, and videotaped post-session interviews.

## Procedure

The following are the steps that were followed during the study. The participants were ranked by National Board of Medical Examiner (NBME) Step 1 scores. Quartiles were established and three students from each quartile were randomly chosen and identified. These students were chosen by the Senior Associate Dean for Education and the Associate Dean for Clinical Education. The Department of Emergency Medicine research staff contacted each student to obtain consent for the study and schedule a time at the simulation center.

Once the student arrived at the simulation center, he or she was briefed on the equipment, expectations, and flow of the study. The case then commenced and was videotaped. After the completion of the case, the student was given the opportunity to complete a written summary (history and physical examination, diagnostic data and interpretation, medical decision-making, and placing orders). The student then presented the case orally to the faculty member, which was also videotaped. On completion of the oral presentation, the student was asked: "What were your thought sequences that lead to the differential diagnosis, final impression, and disposition?" "What was your perception of simulation?" The answer was videotaped and transcribed.

## Sources of Data

Three sources of data were obtained regarding this single case. They are the written note, videotaped session of the simulation case, and videotaped post-session interview which included the oral presentation.

**Written Note**

The written note was information gathered by the student from several sources: obtaining the history from the patient, examination findings, diagnostic data and interpretation, summary of the progression of the case, procedures completed, discussion of diagnoses considered and final diagnosis, and plan for further care. It is the written summary of the entire case as the student views it.

**Videotape Simulation Session**

The simulation case was videotaped so information important to the case can be reviewed and compared to the written note. This is to assure that key information from the case is noted appropriately in the written note. This allowed me to also record nonverbal communication such as body language, procedural technique.

The session also included a videotaped session that mimics the oral presentation to the supervising physician.

**Videotape Post-Session Interview**

A post-session videotape was also completed. The participant presented the case orally as they would during actual patient care. Also, during this time the questions "What is your thought sequence that led to the differential diagnosis, final impression, and disposition?" and "What is your perception of simulation?" were asked. The videotape allows for easier review and inspection for accuracy of the result. The open question was chosen as Creswell (2013) suggested so the participant is treated equally in the interview. This procedure ensures the researcher's agenda and interpretation does not

inhibit the participant from the discussion. This interview was transcribed, coded, and reviewed for thematic categories.

## Data Analysis

I developed a rubric for this study. Thematic analysis was completed using an a priori method.

### Rubric Development

The Association of American Colleges and Universities (n.d.) developed and validated a series of rubrics. The AAC&U VALUE Critical Thinking Rubric (2013) (Appendix B) was selected as a basis, which assessed five components: Explanation of issues, Evidence (selecting and using information to investigate a point of view or conclusion), Influence of context and assumptions, Student's position (perspective, thesis/hypothesis), and Conclusions and related outcomes (implications and consequences). Using the steps described by Mertler (2001), the criteria or dimensions were amended and each element defined to reflect medical education and specifically the care of a patient. Also, Northwest University Feinberg School of Medicine, John Carroll University, Texas A&M Health Science Center College of Medicine, and Loma Linda University School of Medicine clerkship evaluation rubrics were reviewed for content as it applied to critical thinking.

Several iterations were required until a final rubric was developed. The first draft contained too much detail within each dimension to be an effective tool to distinguish between the scales. See Appendix C. The details were summarized and shortened to allow better discrimination between the scales. See Appendix D. Each modified rubric

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was then reviewed by a panel of experts with clinical content and assessment expertise within Loma Linda University. The simulation case and the checklist of themes (see Appendix E) developed by Nguyen et al. (2009) served as a backbone for the rubric development. Facione and Facione (1996) state a rubric may be internalized as a checklist. The final rubric was agreed upon by the panel. See Appendix F.

The dimensions were retitled to Comprehension, Acquiring, Analysis, Evaluating, and Application. Comprehension was defined as understanding the patient's problem(s), Acquiring as gaining new information based on differential diagnosis, Analysis as defining the key components within the context of the patient problem(s) and differential diagnosis, Evaluating as integrating knowledge and expertise for decision-making, and Application as solving the problem safely and effectively. See Appendices C and D. The final rubric (see Appendix F) contained enough detail to score the simulation experience.

The data was analyzed using this rubric (see Appendix F) developed for this study. Driscoll and Wood (2007) describe rubrics as "tools for grading student evidence with detailed descriptions of expectations for the work as well as of the levels of performance for each component" (p. 107).

I analyzed the simulation case including each mode of communication (written and oral) for critical thinking using this developed rubric, "Critical Thinking Assessment Rubric," in both the written and oral communication (see Appendix F). A pilot study was conducted to make final adjustments to the assessment tool and provide opportunity for the raters to refine their assessment technique. The expectation for this study was all participants would score either "meets expectations" or "above expectations" in all dimensions.

Thematic Analysis

At the completion of the oral presentation, the student was asked: "What were your thought sequences that led to the differential diagnosis, final impression, disposition, and your perception of the simulation session? What was your perception of the simulation?" The answers were transcribed and reviewed for themes. Ryan and Bernard (2003) describe themes as a "conceptual liking of expressions" (p. 88). They also describe an *a priori* approach that I used to determine themes based on professional literature, my values, and personal experience. The themes were divided into internal resources, those themes that are intrinsic to the learner and external resources, those themes related to the checklist (see Appendix E).

Attride-Stirling (2001) describes six steps to thematic analysis. Step 1 is coding the material, which consists of devising a coding framework and dissecting the text into segments. The coding framework was divided into two categories: internal and external resources. Internal resources include topics such as knowledge base, internal value system, and communication skills. External resources include data obtained from the patient, monitoring devices, diagnostic data.

Step 2 is identifying themes. Ryan and Bernard (2003) stated repetition is one method to easily identify themes, which they further described as topics that surface repeatedly. Attride-Stirling (2001) recommended looking for common, relevant, or significant themes by repetition. The themes are then refined in this stage.

Step 3 is constructing networks. The themes are grouped based on content, creating groups of themes based on collective issues. The end product is a global theme for each grouping.

Step 4 is describing and exploring the thematic networks. The content of each global theme and grouping is supported with text segments until underlying patterns appear.

Step 5 is summarizing the thematic network. A summary of the main themes and patterns representing them is presented.

Step 6 is interpreting the patterns.

## Validity and Reliability

Creswell (1998) asks the question "How do we know that the qualitative study is believable, accurate, and 'right'?" (p. 193). Stake (1995) asks a similar question, "Did we get it right?" (p. 107). These questions are related to validity of a qualitative study. Guion, Diehl, and McDonald (2002) note validity in a qualitative study is to determine if the findings of the study are true and certain. They define true as the findings reflect accurately the real situation and certain as there is no reason to doubt the results. Eisner (1991) noted, "We seek a confluence of evidence that breeds credibility, that allows us to feel confident about our observations, interpretations, and conclusions" (p. 110). He uses the term credibility to describe the validation of the study.

Several processes of validation, credibility, or verification, are described. Lather (1991) lists triangulation, construct validation, face validation, and catalytic validation. Creswell (1998, 2013) lists eight strategies and "recommend(s) that qualitative researchers engage in at least two of them in any given study" (2013, p. 253). For a case study Stake (1995) suggests triangulation. In addition external audit was also employed to assure validity. For this study, two methods of triangulation were used: triangulation with diverse sources and an experienced physician educator.

To assure validity of my findings, triangulation was utilized. Triangulation as described includes using several and diverse sources, methods, investigators, and theories to provide corroborating evidence (Creswell, 2013; Guion et al., 2002; Merriam, 1988). In this study, the videotapes and oral and written summaries served as the corroborating sources. The oral presentation transcription was reviewed with the written note and both compared to the videotape of the case to examine for accuracy of information documented. Investigator triangulation consisted of scoring by me along with an experienced physician educator from the School of Medicine. We utilized the same rubric to evaluate the written and oral presentations.

The external audit was completed by a consultant who reviewed the results, analyses, and conclusions to assure they were supported by the data (Creswell, 2013). Creswell also describes this as the interrater reliability of the study.

Merriam (1988) defined reliability as "the extent to which research findings can be replicated" (p. 205). Creswell (2013) suggests the intercoder agreement as a method to assure reliability of transcript data. Using intercoder agreement, assures the stability of multiple coders' analysis of data.

The data from three cases were coded independently by me and the physician educator. The videotaped and written and oral presentations were assessed independently by me and the physician educator, using the Critical Thinking Assessment rubric. Each dimension of the rubric for the three cases was reviewed in conference for agreement.

The transcribed data for those cases were coded independently and a codebook of major codes was developed (see Appendix G). This codebook contains a definition of

each code and text segments. For any disagreement or differences, the evaluators reviewed the items and determined consensus.

## Institutional Review Board

To meet IRB requirements for the participating institutions, the completed research protocol was submitted with informed consent forms. I have completed the Collaborative Institutional Training Initiative, which is mandatory at Loma Linda University (LLU) and assured the certification remained active during the course of this study.

All data were kept confidential and secure. The names of subjects or other identifying links are not included in any publication of study results. This study was carried forward with respect for the participants. Their participation was considered voluntary and informed.

## Summary

This study is an instrumental case study with a single simulation case with multiple participants, who were chosen by purposeful sampling, completing the same case. They completed a written summary and oral presentation of the case and were interviewed after the case. The simulation case, oral presentation, and interview were videotaped. The interview was transcribed and coded.

CHAPTER 4

RESULTS

**Introduction**

The purpose of this study is to analyze how high-fidelity medical simulation

performs as a tool for assessing critical thinking skills in senior medical students. A

single high-fidelity mannequin was used as the patient who had the same clothes and

physical appearance for each case. Each participant managed the same critical patient

encounter, 63-year-old male with a complaint of "not feeling well." The patient was

hypotensive, tachycardic, and febrile at the start of each case. The data each participant

obtained was determined by their individual variation in management of this case. The

overarching research question to be answered was: How is high-fidelity medical

simulation an effective assessment tool for critical thinking in senior medical students?

This overarching question was addressed by three specific questions:

      1.   In what ways does medical simulation provide an assessment environment

similar to an actual patient encounter where critical thinking is crucial for patient safety?

      2.   In what ways does the senior simulation case provide a summative patient

experience for assessing critical thinking competency for beginning post-graduate year 1?

      3.   What was the student's thought sequence that led to the differential diagnosis,

final impression, disposition, and his or her perceptions of the simulation?

      Each student or participant was given the same case. They provided care in the

manner, which a physician attending the patient would. They had available a nurse in the room, pharmacist consultant by phone, equipment required for key procedures, and a visible patient placed in a room similar to an intensive care unit or emergency department. The simulated patient voice was assumed by the same person for all cases. See Appendix H for the simulated patient script.

After the simulation session, the students presented their oral case discussion and were interviewed regarding this case. They discussed a range of topics, which have been summarized by six themes: assessment environment, coalescence of knowledge and skills, decision-making and depth of reasoning/thinking, integrative experience, lack of depth in the thought process, and safe environment. Themes one and two correspond to Research Question 1, themes three and four to Research Question 2 and themes five and six to Research Question 3. The next section presents findings regarding each theme. Support for the findings was presented in participants' own words. See Appendix I for the interview questions.

Their patient encounter was videotaped to develop a summary timeline of interventions completed by the participants, but also to verify actions taken by each participant. The videotape was also reviewed to confirm accuracy of their written documentation.

This chapter is organized into five sections. The first section describes the demographics of the participants. The second section describes evaluation of participant's critical thinking utilizing the rubric. The third section describes the simulation assessment environment. The fourth section describes the participant case experience. The fifth section deals with the students' thought processes and their views of simulation.

## Description of Participants

All participants were senior medical students. An email was sent to the senior

class and participants were selected in sequence from all the students who responded to

this email. The Associate Dean for Clinical Education reviewed this list to assure the

sample represented high and low student academic performance. The quartiles were used

to determine where the participant's academic performance was ranked. Each participant

was consented and entered into the study. This was a purposeful sample, since all

students were senior medical students at Loma Linda University, School of Medicine.

To be designated a senior medical student at Loma Linda University, a student

must successfully complete two years of foundational science courses and the following

clinical courses: Medicine, Pediatrics, Obstetrics and Gynecology, Surgery, Psychiatry,

Neurology, and Family Medicine and pass the Step 1 examination for the United States

Medical Licensing Examination (USMLE). To protect the privacy of the participants,

they were assigned fictitious names.

Participants Allan, Bailey, and Caden were in the latter portion of the senior year.

These students had also completed the senior required clinical coursework, which

includes Emergency Medicine, Sub-Internship, and Intensive Care. The Sub-Internship

and Intensive Care coursework may be completed in the following specialties: Pediatrics,

Internal Medicine, or General Surgery.

Family Medicine provides only a sub-internship rotation. The sub-internship

course allows the student to function more independently, taking more responsibility for

the care of the patient. The goal for the student in this course is to function like an intern

in the first year of residency. Critical thinking is formally assessed in the sub-internship

rotation. A summative process is used to evaluate critical thinking. Students are directly observed by the faculty physician who is caring for the patient, during case presentation. The students are asked probing questions to determine their thinking process and depth of understanding of the problem and determination of care plan. These questions are also directed at understanding of foundational knowledge and its application to patient care. The Intensive Care clinical experience allows the student to actively participate in the care of a critically ill patient. Students are closely supervised on these rotations due to accreditation requirements as well as patient safety.

Earl, a senior student who chose to complete the senior year in 2 years, this being his last year, had completed all his senior coursework as well. The other eight participants were at the start of their senior year. They had only completed the Emergency Medicine course.

There were nine male participants and three female participants. Eight participants were applying for Emergency Medicine residency; two were applying for Neurosurgery, one for Pathology and another one for Radiation Oncology. All female participants were applying for Emergency Medicine. These four specialties have higher academic expectations of its applicants.

The students are required to take Step 2 of USMLE at the start of the senior year. Participant scores for Step 1 ranged from 218 to 261 (national mean 229, school mean 228). USMLE Step 2 scores ranged from 214 to 271 (national mean 240, school mean 237). The highest score on USMLE Step 1 and Step 2 was obtained by the same student. The lowest score for Step 1 and Step 2 was also scored by the same participant. Table 2 describes the participants.

Table 2

*Participant Description Summary*

| Participant Name | Gender | Senior Year (late vs. early) | Specialty Match | USMLE Step 1 Score | USMLE Step 2 Score |
|---|---|---|---|---|---|
| Allan | Male | 2014 (late) | Radiation Oncology | 241 | 246 |
| Bailey | Male | 2014 (late) | Not matched—PhD | 257 | 253 |
| Caden | Male | 2014 (late) | Not matched—PhD | 250 | 229 |
| Daisy | Female | 2015 (early) | Family Medicine | 219 | 224 |
| Earl | Male | 2015 (early) | Pathology | 218 | 217 |
| Faith | Female | 2015 (early) | Transitional residency | 236 | 248 |
| Garrett | Male | 2015 (early) | Emergency Medicine | 223 | 241 |
| Harold | Male | 2015 (early) | Emergency Medicine | 220 | 248 |
| Isaac | Male | 2015 (early) | Internal Medicine | 221 | 214 |
| Jacob | Male | 2015 (early) | Emergency Medicine | 239 | 252 |
| Kim | Female | 2015 (early) | Emergency Medicine | 261 | 271 |
| Lamar | Male | 2015 (early) | Emergency Medicine | 227 | 223 |

## Summary of Critical Thinking Rubric
## in the Simulation Setting

The AAC&U VALUE Critical Thinking Rubric, which assessed five components, was modified for medical education. These modified components were comprehension, acquiring, analysis, evaluating, and application. Several iterations were required until a final rubric was developed. See Appendices C and D. The final rubric (see Appendix F) contained enough detail to score the simulation experience. The final rubric was used to score all three components: the videotaped patient encounter, oral presentation of the case, and the written documentation of the case.

The pilot testing showed the interpretation of participant skill level between reviewers was an issue. After discussion and review of the videotaped cases, consensus was reached. Kappa score was calculated at 0.64, showing good agreement. During validation the process the recommendation was made to slow the rate the simulated patient becomes ill. There was agreement the scales, dimensions, and descriptors of the

dimensions of the rubric were well defined to identify critical thinking. Another issue noted during the pilot was confusion of participants in expectations during the case. A briefing script was developed and read to each subsequent participant prior to the start of the simulation case (see Appendix J). This clarified any confusion.

The summary (Total Score) of the rubric findings show, when looking at the five dimensions of each rubric, participants tended to score "below expectation" as the dimension required more critical thinking skills. Two participants (Jacob and Earl) did not score "below expectation" in any dimension, while Allan, Bailey, Daisy, and Garrett did not score any "above expectation," but also scored the highest number of "below expectation." Their patient outcome was "death." Kim scored only one "below expectation," but also had the highest number (9) of "above expectation." Earl, Harold, and Lamar had the next highest number of "above expectation."

More scores of "below expectation" were given (74) than "meets expectation" (67). Only 39 scores of "above expectation" were given. Using this simulation case to assess critical thinking, only Earl and Jacob would have met the requirements. Allan, Bailey, Daisy, and Garret had the most "below expectation" identifying them as weaker graduates. When looking at each total scores of each dimension, Comprehension scored 9 "below expectation," 19 "meets expectation," and 8 "above expectation." Acquiring scored 16 "below expectation" with 13 scoring "meets expectation" and 7 "above expectation." Analysis scored 15 "below expectation," 14 "meets expectation," and 7 "above expectation". Evaluation scored 17 "below expectation" with 8 "meets expectation" and 11 "above expectation." Application scored 17 "below expectation" with 12 "meets expectation" and 7 "above expectation." A trend to "below expectation"

was seen as critical thinking becomes more important in patient care. Table 3 summarizes the rubric scoring for each component.

## Assessment Environment

This section deals with the assessment environment provided by the simulated patient and the patient care area, to answer in what way does medical simulation provide an assessment environment similar to an actual patient encounter where critical thinking is crucial for patient safety (Research Question 1). Data will be presented from participants' voice and the rubric.

Although students participate in patient care during their clinical experience, they are always supervised. This clinical teaching environment does not allow the supervising physician opportunity to evaluate critical thinking skills adequately. Furthermore, critically ill patients are cared for by more experienced resident physicians because of patient safety. This case allowed the participant to function as a resident.

### Theme #1: Immersion in "Real" Environment

The simulation center allows the participants to immerse themselves into the case. The environment mimics patient care areas found in the hospital. This environment includes staff, sounds, and equipment. The participant was allowed to function as the physician within the "real" experience.

The simulation center provided a real experience. Five participants described the assessment as real. Jacob stated, "I feel like you learn more because you have to do everything and that way when we're out in the actual hospital we do have people to ask if we aren't sure. But I think doing the sim labs on our own, you can't rely on the smarter

Table 3

*Participant Rubric Summary*

| Participant Name | Video Scoring | | | | | Oral Presentation Scoring | | | | | Written Documentation Scoring | | | | | Participant Summary Total Score | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Com | Acq | Ana | Eval | App | Com | Acq | Ana | Eval | App | Com | Acq | Ana | Eval | App | Bel | Meet | Above |
| Allan | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 12 | 3 | 0 |
| Bailey | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13 | 2 | 0 |
| Caden | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 7 | 5 | 3 |
| Daisy | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 11 | 4 | 0 |
| Earl | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 0 | 7 | 8 |
| Faith | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 11 | 2 |
| Garrett | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 12 | 3 | 0 |
| Harold | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 3 | 1 | 1 | 3 | 2 | 5 | 3 | 7 |
| Isaac | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 8 | 6 | 1 |
| Jacob | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 0 | 13 | 2 |
| Kim | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 1 | 5 | 9 |
| Lamar | 3 | 3 | 2 | 3 | 3 | 2 | 1 | 2 | 1 | 3 | 2 | 1 | 3 | 3 | 2 | 3 | 5 | 7 |
| Documentation Summary | | | | | | | | | | | | | | | | | | |
| Below | 4 | 4 | 4 | 6 | 5 | 1 | 4 | 6 | 7 | 6 | 4 | 8 | 5 | 4 | 6 | 74 | | |
| Meets | 4 | 3 | 5 | 1 | 3 | 11 | 8 | 6 | 4 | 5 | 4 | 2 | 4 | 3 | 4 | | 67 | |
| Above | 4 | 5 | 3 | 5 | 4 | 0 | 0 | 0 | 1 | 1 | 4 | 2 | 3 | 5 | 2 | | | 39 |

1—below expectations
2—meets expectations
3—above expectations

people in the class to know all the answers." Lamar described his feeling of the patient deterioration this way, "realistic to the point where I was feeling like 'Oh, shoot' because his blood pressure was dropping; his sats were dropping." Bailey when asked to further describe the realness stated, it "gives you a sense of being in the hospital." Caden stated, "I mean I think it is very realistic, except that it's just you can't have a real person in there simulating it because they can't do all the things the mannequin can do."

Three participants felt the experience was hands-on. Garrett stated, "So I definitely appreciate the hands-on. Even though sometimes I really don't know what's going on, I always end up walking away thinking like, 'Ok well, I kind of learned something.' Or if I see this again, this is how I'd approach this differently or like that." Jacob described the hands-on experience bringing into practice knowledge from simulation sessions. He described it, "because when you see those types of patients actually in the emergency department code, like I did, it definitely sticks a lot more from the past, from sim lab versus like reading a book about it. Things stick so like 'Oh, I need to know this because I saw that previously."

Five participants described the sessions as an unhuman appearance. Harold stated, "The hardest thing about a simulation, because of the accelerated clock, I'm on the gun and I have to think faster." Isaac described it as "everything happened very quickly, as opposed to a trauma where you get a call, you get to prepare and plan your steps ahead . . . Everything moved very quickly." Kim noted, "I couldn't hear the difference between the rubber and actual lung sounds."

Nine participants made 19 references to the simulation case as a venue for self-assessment. Garrett stated, "They're stressful, but I think I learn best by making mistakes

and then seeing how I can improve on them and that's what I like about simulation." He also noted, "Simulations probably have been some of the best learning I've had in med school. Just because I view myself as more like a kinesthetic learner and sometimes sitting and reading books can be difficult for me." Harold noted, "They [simulations] give me the chance to both show that I'm clinically progressing and learn a lot about the management and the response of patients based on the decisions I make." Each of the participants' self-assessments was based on errors they made in the case.

A summary of the 19 references shows the participant's ability to reflect, determine the errors, and develop a plan for what learning/instruction still needed. Their responses showed an integration of information from various sources they had omitted in their critical thinking.

Caden made three references to being watched. He stated, "It just makes me nervous because someone's watching, being evaluated." He added, "I'm just being judged or graded."

These participants, although feeling watched and judged, did feel this was a good method for learning and self-assessment. It was real, hands-on, though the mannequin could be unhuman. This environment is conducive to assessment, be it self-assessment or summative assessment.

Theme #2: Coalescence of Knowledge and Skills

The simulation environment allows the student opportunity for application of knowledge and skills. Where application of knowledge and skills occurs commonly is within the hospital teaching environment. But multiple levels of learners are present with various learning and evaluation requirements, which often lower level learners (medical

students) are not allowed to participate and cannot be assessed well. This theme describes the participant's application of knowledge and skills.

The size of student groups in the simulation sessions can inhibit students from actively participating. Eight participants commented on the group size being an issue in previous simulation sessions. Earl noted, "When there's a bunch of people standing; they're not doing anything. It's hard to get them all engaged in the process that's supposed to occur in simulation. So I feel like this on-on-one thing is really good." Kim further described another group size issue, "A lot of times in classes you go in with a whole group and you can always say, 'Oh I don't know what to do' and defer to somebody else." Isaac described it as "team building, team work," "fill in the pieces of the puzzle, interacting with others, and you also can verify with others 'Does this one sound good?'" The group approach does not give the student a summative experience of functioning more independently. The assessment is based on group participation. Jacob commented, "Doing sim labs on your own, you can't rely on the smarter people in the class to know all the answers and [letting] you kind of sit back." Application of knowledge and skill is considered a group activity because they depend on each other to fill-in the missing information and collectively manage the simulation case.

Management plan and disposition of the patient incorporates learned knowledge and skills. In real patient cases it is not a group activity, but calls on an individual physician's knowledge and skills. Eleven participants selected the intensive care unit (ICU) for admission based on several factors and procedures that were performed on the patient. Harold described his melding of knowledge and skills by choosing the ICU, "because the patient's blood pressure was still very unstable. He was not saturating well.

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I believe he would probably need more pressors, and I figured this would be managed in the ICU."

Daisy summarized best, "Since he was in critical condition, I tried to move him to ICU." A synopsis for the ICU admission included the patient had a life-threatening condition, septic shock, hypoxia, low blood pressure receiving medication (pressors), intubation and ventilator support, and surviving a Code Blue. They had to pull information from various sources to integrate into case. Not all participants chose admission; this was due to the "death" of the patient during the case.

Rubric Results

The rubric was applied to each participant's simulation session defined by three areas. These areas were videotaped patient interaction, oral presentation of the interaction, and written note reflecting the patient interaction. This should represent the participant's critical thinking skills. Appendix G lists the codes for each rubric dimension.

**Videotaped Patient Encounter**

The results from the videotape rubric scoring showed participants initially speaking with the patient to obtain information, but as tasks required critical thinking skills, several participants made errors. Eight participants scored either "meets expectation" or "above expectation" in Comprehension, Acquiring, and Analysis, but on Evaluation only six participants scored "meets expectation" or "above expectation." and Application only seven scored "meets expectation" or "above expectation." Caden, Earl, Harold, Jacob, Kim, and Lamar did not score "below expectation" on any dimension.

They safely treated the patient and admitted him to the intensive care unit. Bailey, Daisy, Garrett scored "below expectation" on all dimensions. They missed key interventions or failed to obtain facts either from the patient or physical examination, and missed information from the monitor, to prevent "death." Faith scored "below expectation" Acquiring and Evaluation while Allan scored "below expectation" in all categories except Acquiring.

Allan, Bailey, Daisy, and Garrett's cases ended in the "death" of the patient. During the case they were slow to intervene. Although they obtained some information from the patient, they did not obtain all critical information. Once the patient began to deteriorate, their interventions occurred too late or not at all. They recognized the abnormal vital signs, but did not intervene.

The results of videotape scoring based on the rubric, showed an increase in the number of participants scoring "below expectation" in the Evaluating (6) and Application (5) dimensions, which require critical thinking. Fewer students scored "meets expectation" in Evaluating (1) and Application (3). Eight participants scored either at "meets expectation" or "above expectation" in Comprehension and Analysis with seven, scoring in Acquiring.

**Oral Presentation**

The rubric scoring of participant's oral presentation showed fewer scoring "above expectation." More participants had scores of "meets expectations" in the oral presentation and only two participants, Earl and Lamar, had one dimension where they scored "above expectation." Kim scored "meets expectation" in four of the five dimensions, except for Application, where she scored "below expectation."

The area scoring the highest number of "meets expectation" or "above expectation" was oral presentation Comprehension dimension. Eleven participants scored "meets expectation." A synopsis of the expected oral presentation representing this dimension is "Bob Simulation is a 65-year-old male, with emphysema and diabetes, who presents complaining of not feeling well. He has had a productive cough and fever over the past few days. His sputum is foul tasting, but he cannot recall the color. He does report chest pain, but only with coughing. He also describes shortness of breath. He denies nausea, vomiting, diarrhea, blood in his sputum, night sweats, and dysuria. He does not report any surgeries. He is a smoker, but has quit." Allan was the only participant who scored "below expectation" in the Comprehension dimension. He did not obtain or report the patient's smoking history.

Since Acquiring, Analysis, and Evaluating require interventions based on integration of information obtained from the patient as well as real-time from the cardiac monitor and response to initial intervention(s), more participants scored "below expectation" as critical thinking became important in decision-making. Earl, Faith, Jacob, and Kim scored "meets expectation" or "above expectation" in these three dimensions. All other participants had at more than one score of "below expectation." Bailey, Daisy, and Garrett scored "below expectation" in all dimensions of the videotape rubric, conveyed this information in the oral presentation, but the improvement was in the Comprehension and Acquiring dimensions. Acquiring consisted of obtaining information from sources other than the patient. This includes physical examination, vital signs, and diagnostic data. Harold, who scored "above expectation" in all dimensions in the videotape, failed to convey the vital signs, physical examination findings, and diagnostic

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data. A summary of the oral presentation by participants scoring "below expectation" in these three areas was "[the patient's] vital signs show hypotension and tachycardia. I heard crackles on examination. Then his blood pressure dropped and I had to intervene. I gave him a bolus of saline." They failed to incorporate the diagnostic data obtained. A summary of the oral presentation by participants scoring "meets expectation" or "above expectation" was "[the patient] had a temperature of 37 degrees Celsius. His pulse was 104, a little tachycardic. His respiratory rate was 24 and he was [saturating] at 97%. His physical examination showed him to be sick appearing, but he was talking. He was tachycardic without extra murmurs. On his lung examination, I heard some crackles in the right lower base. I ordered labs and imaging. His chest x-ray showed infiltrates in the right lower lobe. His labs should a mild acidosis. His white blood count was 34, glucose of 250. I gave him a bolus because of the low blood pressure."

Evaluation and Application dimensions are areas where participants determine the best management to safely and effectively care for the patient. It was integrating knowledge and expertise, which are key elements to critical thinking. Earl, Faith, Jacob scored at least "meets expectation" in these areas. The other nine participants either were "below expectation" on one or both dimensions.

The trend in the rubric for oral presentation was 11 participants communicated the patient's problem, but fewer were able to communicate their critical thinking in decision making and management of the patient. The oral presentation is another avenue of communication between healthcare providers. It should reflect information and actions taken based on the interpretation of the information. The oral communication should reflect the actual happenings.

**Written Documentation**

The written note is an avenue of communication or reporting of information between healthcare providers. It is a record of information obtained, interpretation of this data or facts, interventions or lack of interventions taken, reasons for the intervention or lack of interventions, and diagnosis. If a procedure is completed, the steps of the procedure, medications used, patient physical assessment pre- and post-procedure, and any necessary imaging should be documented in a procedure note within the written note. The written note is part of a patient's permanent medical record. The rubric was used to assess the conveyance of information and transpired activity. The note should reflect the actual happenings and the reasoning for the intervention or activities.

Allan, Bailey, Caden, Daisy, and Garrett, scored "below expectation" in four dimensions for their written documentation of the patient encounter. They lacked the written ability to understand and formulate a clear plan for the patient's problem(s). Allan's note lacked any depth. He gathered information, but did not document the interventions and his reasoning for completing the interventions. Bailey's also note lacked depth of the case. It resembled a report of facts, but did not discuss any diagnostic data. His diagnosis was "Emphysema Exacerbation," missing the low blood pressure, fever, and chest x-ray findings indicating pneumonia with sepsis. Although Daisy's note showed more understanding of the problems, she also lacked reasoning and analysis. Her documentation did not mention CPR or "death" of her patient, but rather reflected what she would recommend being done. Caden performed better during the actual patient encounter, but his written documentation lacked the details of what occurred and reasoning. He did not document a physical examination, including vital signs, which

allows one to gain new information and can influence your interventions. He had to provide CPR as well, which was not documented. His patient was revived, because he intervened correctly; once again, this was not documented.

Isaac scored "below expectation" in three categories. His written note lacked depth of reasoning as well. He did not document a diagnosis, but during the videotaped patient encounter, thought the anemia was due to a "GI [gastrointestinal] bleeding" or from "trauma." He also initiated CPR for the patient, but revived the patient. This was documented cursorily in the note, "CPR was initiated and pt. [patient] was resuscitated." He did not list the "epinephrine" he ordered during the CPR. His written documentation does not include any physical findings.

Harold and Lamar scored "below expectation" in only one dimension: Acquiring. Earl, Faith, Jacob, and Kim scored at least "meets expectation" or "above expectation" in all categories.

Earl's written documentation scored "above expectation" in all categories. He identified problems that occurred during the patient case along with each intervention he ordered and the result. It matched what occurred during the videotaped patient encounter. Although he scored "meets expectation" in comprehension, acquiring, and analysis for the patient encounter, he written note clearly reflected his thought process. Since time was important in intervening to the patient's worsening condition in the actual case, the written note allows the participant more leisure to thoughtfully document.

Faith, Jacob, and Kim's written documentation also scored either "meets expectation" or "above expectation" in all dimensions. They had described the patient's story clearly and defined the issues. The physical examination, which is another avenue

to gain information, was focused. No participant documented a procedure note, despite completing intubation, central venous line, or cardiopulmonary resuscitation.

## Summary

Medical simulation provides an assessment environment that is immersive and real, allowing the participants to function as the physician providing care for this ill patient. The patient care room contained the same equipment found in hospital patient care area. The monitoring equipment made the same sounds, although the simulated patient did not have the facial expressions as a real patient.

Participants had to rely on their own learned knowledge and skills to provide appropriate and timely interventions. Several noted this was the first time they were allowed to function alone, without a group or supervising physician providing answers. Although, several participants' cases ended in "death," patient safety was not compromised with simulation and participant critical thinking skills still were assessed.

Critical thinking was defined as a complex process of skill or ability, integrating knowledge and expertise to solve patient problems and to achieve safe and effective patient care. Critical thinking was evaluated in the rubric dimensions of analysis, evaluating, and application. The simulation session also allowed for the participants to be assessed in real-time with the interventions they performed and in accuracy of their written and oral communication utilizing the rubric.

## Summative Patient Experience for Assessing Critical Thinking

Since medical students are required to be supervised as unlicensed learners, completing a summative assessment for critical thinking is a difficult task. Upon

graduation, they are entrusted to recognize critical patients and initiate care. Summative assessment of this entrusted activity prior to graduation is crucial. In what ways does simulation provide a summative assessment for critical thinking? (Research Question 2).

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Theme #3: Decision-Making and Deep
Thinking/Reasoning

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In undergraduate medical education, the students are expected to be supervised. Accreditation Element 9.3 states, "A medical school must ensure that medical students in clinical learning situations involving patient care are appropriately supervised at all times in order to ensure patient and student safety" (LCME, 2014, p. 19). Student's decision/intervention on any patient care rendered is with the consent and supervision of a licensed (faculty) physician. Simulation allows the student the opportunity to function in this independent role, without compromising safety. Students do not experience resource management. Englander (2013) describes systems-based practice competency domain as the ability to "demonstrate an awareness of and responsiveness to the larger context and system of health care, as well as the ability to call effectively on other resources in the system to provide optimal health care" (p. 5). This includes management of resources at the participant's disposal. His descriptions include the ability to be cost aware, provide quality care, risk-benefit analysis, understanding the hospital system and its resources.

Earl commented on being the decision-maker. He stated, "So I feel this one-on-one thing is really good for me, plus [I'm] more engaged and [it] helps me think more than [just] 'I don't know.'" Harold described his experience in this realm as "I think that's ultimately to my benefit because you learn to react quicker and process you

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decisions faster but it does sort of make you sweat a little bit as the participant because you're very worried you're going to miss something."

Caden spoke of his resource utilization this way, "I mean it also teaches you to be more resourceful like I had to call the pharmacy a lot, like [I] had to call for somebody to help me intubate." "I need to give some Zosyn and ceftriaxone. Pharmacy recommended Zithro (*sic*) so I knew what antibiotics but not the dosage." Kim said, "If I had stepped back," realizing she did not process all the information available regarding the patient. Processing this information, she would have made different decisions in the management.

Every participant made critical decisions in their case resulting either in stabilization of the patient or in "death." All participants requested help from a pharmacist, showing their utilization of resources available, when their knowledge gaps were recognized.

Summary Timeline of Case and Documentation

The summary timeline (see Table 4) shows the progression of activities and participant interventions during the case. As in any patient case, the participants have a question about the patient. All participant questions were "What are you here for?" They then proceed to asking questions of the patient to answer their question. While they asked questions and were talking to the patient, they looked up at the monitor. The monitor had vital signs, which were abnormal. Every participant looked at the monitor about one minute into the case, but did not intervene. The average time for the participants to look at the monitor, pause to assess the meaning, and intervene was five minutes. Participants, who successfully managed the case (no "death"), looked at the monitor, paused, and intervened three minutes sooner than those whose cases ended in "death." The orders

Table 4

*Timeline*

| Timeline | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Start | Patient history | Low blood pressure and oxygen levels | Diagnostic tests ordered | | Procedure: Central venous line, intubation, blood transfusion | Disposition | End |
| Student has a question | Look at the monitor | Order oxygen and saline bolus | Reassess, Determine patient response, antibiotic, vasopressors | | | Admit to the ICU or "death" | |

commonly completed were oxygen and saline bolus, which were completed by the nurse.

This timeline shows the iterative process used by the students to gather information, followed by assessment of the meaning of the information, then creating a working diagnosis. With this working diagnosis, they obtained more information, either from external or internal sources, assessed its meaning which led to an action. This action was either interventions or consultation. There was a continual reassessment and integration of information. The difference between participants' performance was depth of questioning and passing of time.

Participants after completing the history and physical examination, ordered diagnostic data, such as chest x-rays and blood tests to support their working diagnosis or differential diagnosis. Several participants included diagnoses that were not part of the case. Garrett noted he was "thinking, maybe, he [the patient] was having heart issues. I wasn't sure just because he was tachycardic."

Earl discussed sepsis and shock, but added, "I was thinking [the patient] had ARDS" (Adult Respiratory Distress Syndrome) instead of recognizing pneumonia. Isaac

added he "wanted to throw in PE [pulmonary embolus] as well." He also was concerned about "bleeding" and "trauma." Jacob brought up the issue of "TB because of the cough" but it "didn't seem that serious when I walked in."

Although Kim initially thought of sepsis, she "considered the most common sources" so "asked him [the patient] about urine, it could be a urinary infection. I asked him about any skin infections he had, because that could be a common one. Diarrhea, vomiting and that kind of stuff for GI."

Eight participants noted the physical examination was important in their development of the working diagnosis. Ten participants felt the history obtained from the patient played a key role in the working diagnosis. All participants integrated components of each during their discussion.

While diagnostic tests are being completed, the participants continue reassessing the patient to determine response to their interventions. In the written documentation, no participant documented the reassessment. Several participants never reassessed the patient because they failed to intervene in a timely fashion and the patient proceeded to "die." The patient gave the participants multiple cues of his worsening condition by stating, "I don't feel good." These participants did not process the information from the patient, monitor, and diagnostic data. Four participants' cases ended in "death," while eight successfully resuscitated the patient for admission to the intensive care unit. The "deaths" were a result of failure of instituting timely interventions or recognition of the severity of illness.

### Theme #4: Integrative Experience

This theme describes the ability of the students to integrate knowledge, skills,

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behaviors, and attitude. The participants had to pull from everything they have learned to determine the care plan based on the differential diagnosis. They needed to look at various elements that provided them vital information. External sources included the monitor, history from the patient, physical examination findings, and diagnostic data. Internal sources of information were related to the participant (see Appendix E).

The monitor provided information such as heart rate, respiratory rate (tachypnea), temperature, oxygen saturation, and blood pressure. The most commonly mentioned abnormal vital signs were the rapid pulse rate (tachycardia) and low blood pressure (hypotension). Kim summed up the monitor information key to the case: "I initially looked at his vital signs. He was a bit hypotensive and tachycardic and was febrile, and had a poor oxygen saturation, so that was kind of concerning."

Historical facts from the patient that were key to the case were fever, cough, shortness of breath, malaise, past medical history (hypertension, chronic obstructive pulmonary disease (COPD), diabetes), and a social history of smoking. Eleven participants noted the historical facts as important. Earl did not mention these facts to be important in his critical thinking. All 11 participants mentioned fever and cough as important factors. No participant mentioned the shortness of breath or malaise as playing a role in their critical thinking.

The physical examination findings that were abnormal in this case were the crackles on lung examination consistent with pneumonia and rapid heart rate. Although these findings are not listed as key components to decision-making, it helps guide the location and severity of the infection. Eight participants mentioned the examination played a role in the differential diagnosis. All 8 mentioned the crackles on lung

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examination. In addition Isaac mentioned the appearance of the patient, that he "didn't look good; he didn't feel well; he looked toxic." Four participants mentioned the tachycardia on examination.

Diagnostic data key to this case are lactate level, hemoglobin, blood cultures, and chest radiograph. Although blood culture results are not available for at least 24-72 hours, they are important to obtain on the initial presentation of the patient, to guide appropriate antibiotic therapy after admission. Ten participants obtained a hemoglobin level as part of the complete blood count (CBC). Only three participants recognized the need for a lactate level, while 11 requested a chest radiograph. Only six ordered blood cultures. One participant did not order any diagnostic data due to the complexity of the patient, although she stated she would have obtained diagnostic data. Earl and Garrett mentioned the patient meeting SIRS (Systemic Inflammatory Response Syndrome) criteria indicating an attempt at tying the pieces of information together to define the problem. When asked to define these criteria, neither participant could list the four components (temperature, pulse rate, respiratory rate, and white blood cell count) (Bone et al., 1992).

Earl summarized the integration of knowledge and its application in this manner, "I was thinking, oh, maybe septic (sepsis). But then once I looked at the vitals and everything, I went 'Okay, he's in shock.' Then given the factors point toward sepsis, [this] was septic shock." He went on to describe the patient's condition as playing a role in the decision "since he was in such respiratory distress, I was thinking 'Well, he either has ARDS because of pneumonia or his ARDS [is] secondary to another infectious process.'" He had integrated the monitor findings with his physical examination. Harold also incorporated diagnostic data and clinical appearance of the patient in this fashion, "I

started to become concerned for pneumonia, COPD exacerbation. As he started to further decompensate, and the labs started to come in, then I started to get very worried about sepsis and went down that road, especially based on the lactate and leukocytosis."

Kim considered more diagnoses in their differential based on the patient history. She stated, "I thought of sepsis. I considered the most common sources. That's why I asked him about urine; it could be a urinary infection. I asked him about any skin infections he had, because that could be a common one. Diarrhea, vomiting, and that kind of stuff for GI."

Allan noted an additional component that he pulled into his differential diagnosis. "(The) physical examination findings" of crackles indicate pneumonia or cardiogenic shock.

Bailey noted, "I didn't really take the time to consider an extensive differential diagnosis." Citing the case was proceeding too rapidly; he knew it was "lung versus cardiac."

A summary of elements integrated in making decisions in this case were: 12 participants cited identifying abnormal vital signs on the monitor, 11 participants cited history obtained from the patient, 8 participants cited examination findings, and 10 participants cited diagnostic data. The differential diagnosis pulled on everything they have learned, mimicking reality.

## Rubric as a Summative Assessment

The rubric functioned in identifying participants who have difficulty integrating information and also reasoning in their decision making. Critical thinking was evaluated in the rubric dimensions of analysis, evaluating, and application. Daisy, Earl, Isaac, and

Lamar had low USMLE Step 1 and Step 2 scores, but Daisy and Isaac were the two from this group who had more "below expectation." Earl had no scores of "below expectation" and Lamar only three. Allan, Bailey, and Garret's USMLE Step 1 and 2 scores were above average, yet they scored more "below expectation." Bailey commented, "I did not know where the blood pressure was on the monitor." He felt that he would have done better if he knew where to find information. Allen, Bailey, Daisy, and Garret's decision-making led to their patient's "death."

Caden, Harold, Kim, and Lamar scored "meets expectation" or "above expectation" in the videotaped patient experience, but scored "below expectation" in several dimensions in the written documentation and oral presentation. They had the knowledge to manage the patient, but communication of the encounter needed improvement.

<center>Summary</center>

This simulation case provided summative assessment of critical thinking by highlighting the participant's decision-making capacity, based on their prior knowledge, skills, attitudes, and behavior. This was an integrative assessment case. Participants with weaker knowledge and skills scored more "below expectations." This case provided the opportunity to summatively assess their reasoning for the interventions completed by the discussions in the oral presentation and written note. Grasping concepts from prior knowledge and applying them appropriately in this case, shows a deeper thinking process important to critical thinking, which is important in the practice of Medicine.

The timeline summary from this case provided another aspect of summative assessment important in critical thinking: timeliness of critical (life-saving) interventions.

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When care was delayed, the outcome of the simulated patient was worse. Participants recognized the patient was ill, but what they did and when they intervened is important.

The rubric did identify areas of improvement needed in order to assure the medical student graduates with critical thinking skills.

## Thought Sequence and Perceptions of Simulation

Participants were asked to reflect on this case and identify information or facts that lead them to decisions made about the differential diagnosis, final impression and disposition of the patient. They also reflected on the simulation experience as a whole (Research Question 3).

### Theme #5: Lack of Depth in the Thought Process

This theme describes the failure to recognize gaps in knowledge and/or skills. The discussion from Bailey on not having an "extensive differential diagnosis" alludes to a lack of depth in the critical thinking process. Only two large organ systems were identified as potential etiology of the case. He described this as "lung versus cardiac."

The videotaped simulation sessions review show long pauses as the participants contemplate the next decision to be made based on the information they have available. On the average, it took 3 minutes before oxygen was ordered for the patient, but not all participants requested oxygen for the patient. As the tasks required to manage the case became complex and required critical thinking, the number of participants recognizing this need shrank. The participants were excellent at obtaining needed information from the patient. All 12 participants obtained the chief complaint and past medical history from the patient.

**Evaluation of the Written Documentation**

The written documentation consisted of two items: history and physical

examination (H&P) and written order sheet. The H&P additionally includes results of all

diagnostic tests, medical decision making section which is a narrative analysis of any

significant issues or findings and/or events that occurred during the care which reflects

complexity, and purposed plan and disposition (Services, 2014). The H&P is a

communication system used to convey events that occurred, interventions completed, and

their results, to others caring for the patient. It also serves as a legal document in

malpractice suits to show appropriate care was taken. All participants completed both, but

no participant's H&P or orders contained documentation of tasks done during the case.

Appendix E has themes that should be contained in the H&P and orders.

All participants documented the reason for the patient visit and the past history.

This data was provided to them at the start of the case. Nine participants documented

results of the diagnostic data they obtained. The participants who successfully treated the

patient, showed a basic level of critical thinking within the written note.

Bailey's H&P contained only the information he collected from the patient, but no

details that transpired during the case. The patient required chest compressions, but there

was no mention in the note the patient had "died." His orders contained what he wanted

to do, not what was done. He listed the blood pressure as "BP?" although this information

was given in the chart. His final diagnosis was "Emphysema exacerbation" although the

patient had the signs of sepsis.

Garrett discussed the case briefly and also documented the "respiratory distress"

was likely from "exacerbation of the emphysema" but did mention the exacerbation was

due to "infection." He had to begin chest compressions which ended in the "death" of his patient, but he did not make mention of this in his discussion. Garret scored poorly on his case as well.

Daisy, who performed poorly in the case, documented the historical and physical examination findings, but did not discuss the events that transpired during the case or the interpretation of the diagnostic data. Her case also ended in "death" of the patient, which was not mentioned in the written documentation. Her patient orders reflected her concern for sepsis because she selected "Sepsis Adult Panel" to be completed.

Earl performed well on the case. His written H&P showed some thought process. He noted "patient required intubation due to respiratory distress." His orders reflected what he had done during the case and also the orders for the continued care of the patient. He had successfully treated the patient.

Jacob, Kim, and Lamar wrote discussions, which reflected some complexity required to manage this patient. Kim noted "unable to maintain oxygen saturation on 15L non-rebreather. Intubated in ED." She further described, "patient lost pulse with PEA (pulseless electrical activity) on monitor. Return of spontaneous circulation after 1mg epi epinephrine and CPR." She documented the complexity of her patient care. Lamar discussed the complex factors of the physical examination such as heart rate and blood pressure that lead to the interventions he chose.

Summary of the written notations (H&P and orders) showed participants lacked ability to document clearly and precisely the narrative analysis and complexity of their cases. Written documentation and information conveyed in an oral presentation were

mismatched for all 12 participants. It was not a reflection of the decision-making skills or their deep thinking.

**Evaluation of the Videotape Encounter**

Each participant can be seen grappling with the initial vital signs on the monitor and as the case progressed many demonstrated a lack of confidence in knowledge and skills. Eight participants took more than one minute from the start of the case, before looking at the cardiac monitor.

These participants were engaged in asking the patient questions. Once they glanced at the monitor, they can be seen pondering what to do. Participants, who performed well, intervened quickly at this point. The most common intervention was oxygen and normal saline bolus. Ten participants completed both interventions.

Many participants verbalized their thought process during the case so the nurse in the room also knew their dilemma. They were prompted by the nurse and patient when interventions were not being completed, as would happen in the actual care of critical patients. Those who were uncomfortable with being the sole caregiver for the patient, performed more poorly than the participants who were comfortable with their skills. The participants uncomfortable did not utilize good decision-making skills.

Harold demonstrated confidence in his assessment skills, but lacked procedural skills.

Earl discussed the ventilator settings, but did not know the intubation equipment. He also attempted to place a central venous line, which is not a skill expected of medical students. He reached a certain point and could not continue, but was able to verbalize completion of the procedure.

**Summary of Participant Documentation**

When reading the written documentation and viewing the videotape of the case and oral presentation, there was a mismatch of facts presented. Participants documented less information about critical aspects of the case and narrative analysis than they presented orally. There was a mismatch also in comparing the information obtained in the participant simulation encounter with information conveyed in the written documentation and oral presentation. For example, Bailey completed an endotracheal intubation for the patient, noted this in his oral presentation, but did not communicate this in his written documentation. Caden completed a physical examination during the case, but failed to document this in the oral presentation and written note. Daisy's case ended in "death" of the patient, but this was not mentioned in the oral presentation or written communication. Lamar ordered diagnostic data, antibiotics (ceftriaxone and azithromycin) and vasopressor (Levophed) during the management of the simulation case, but failed to document this and results in his written note, although it was conveyed in the oral presentation.

<center>Theme #6: Safe Environment</center>

Since medical errors cost society billions of dollars, but also loss of life, creating a place where learners' competency can be assessed in high-risk case is important. The clinical education system has changed with simulation. Learners can practice without the risk of injury or harm to patients. Faith stated, "It's a good place to make all your mistakes." Garrett had a similar thought, "I think it's a great place to learn from your mistakes, because in the hospital it's not really good to learn from your mistakes." He also recognized patient safety. Jacob also described the environment, "It's good even if

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you mess up. At least it's controlled and you learn from it." Kim raised the issue of "you don't want to kill the real person; you want to kill the dummy, if you're going to kill someone by a mistake." Daisy added, simulation is "very helpful to learn how to interact with the patient as well as to see critical conditions before actually seeing them on a real patient."

Seven participants viewed the simulation cases as a safe environment. With patient safety provided, this allows the participant to fully engage their knowledge and its application.

## Summary

Participants were adept at obtaining information from the patient, but as the case required integration of knowledge and skills and their application, few participants completed all the required tasks. Their written documentation lacked detail to show narrative analysis of data from various sources and why they completed certain interventions. The oral presentation was better than the written documentation with more analysis discussed.

Participants had a positive view of this case. They felt they did not have an opportunity, in past simulation experiences, to engage in cases without other learners present. This simulation case gave them the ability to make decisions for themselves in a safe environment, without affecting patient safety.

High-fidelity medical simulation as an assessment tool provided an environment for students to manage a complex case ensuring patient safety, but allowed them to utilize their critical thinking skills. Although appropriate management of the patient is imperative, communication and documentation of events and their results are also

important in medical care of a patient. This environment also provided the summative

patient experience necessary for assessment in which patient management and oral and

written communication skills can be evaluated by the rubric created for this study.

CHAPTER 5

SUMMARY, DISCUSSION, CONCLUSIONS, AND

RECOMMENDATIONS

**Summary**

As competency-based medical education is being implemented in medical

schools, medical teaching has expanded assessment to include the learner's cognitive

process. Critical thinking is part of this process, but no system exists to adequately and

safely assess this aspect of the learner's education experience. First, when critical

thinking is described as a process, this leads one to consider steps needed to determine

treatment plan. When it is defined as a skill or ability, it indicates that it may be taught or

learned. A third definition implicates critical thinking as a habit of mind and personality.

Based on P. Facione (1990) and Norman (2005) definitions of critical thinking, a

synoptic definition was developed for this study: critical thinking is a complex process of

skill or ability, integrating knowledge and expertise to solve patient problems and achieve

safe and effective patient care.

To develop the learner's skill or ability for critical thinking, two methodologies

are used in medical education, Kolb's (2005) experimental learning and heuristics

learning. Kolb based his model on the works of John Dewey, Kurt Lewin, Jean Piaget,

William James, and others. The main thrust of his work defined learning as a process of

relearning. He also describes simulation as a method of learning that provides a realistic

encounter. The LCME (2012) describes heuristics as using algorithms or steps to create an appropriate solution to the problem. Bransford and Stein (1984) described a heuristic method, IDEAL. The steps guide the learner to identify the problem, define and represent the problem, explore solution strategies, act on the strategies (trial and error), and look back and evaluate the effects of the activities (reflection).

Dreyfus and Dreyfus (1980) developed a model for skill acquisition describing skill, behaviors and knowledge attributes of the five stages from novice to expert. Based on their description, some medical students fall into the early portion of the second stage: advanced beginner, but most are in the first stage: novice. These learners recognize common situational aspects of their patient cases that are not apparent apart from the experience. They are still rule-governed, but their heuristics skills are better developed. They still require supervision. Stage 3, described as competence, is the level where problem solving is developed and Stage 4, critical thinking skills are evolving. Stage 5, the expert, is fluid, flexible, and efficient. They perform intuitively and respond to stimuli, which may be obscure to the less skilled.

In order to facilitate learning critical thinking in medical courses, faculty developed learning objectives based on Bloom's taxonomy (Plack et al., 2007). Bloom (1956) described a classification system for cognitive, skills, and behavioral learning objectives. This has been known as Bloom's taxonomy or the revised Bloom's taxonomy (L. Anderson & Krathwohl, 2001). The higher-order objectives are considered to show critical thinking skills (Larkin & Burton, 2008). Each successive level builds until the learner reaches the higher order, which for the cognitive domain is evaluation.

Although medical simulation has been used for training or teaching, its use for

assessment of critical thinking has not been studied. Medical students are required to be supervised at all times (LCME, 2012, 2014) and are not permitted to make patient-care decisions without direct supervision. Simulation allows the students to manage and care for their patients unsupervised without compromising safety.

This study looked at high-fidelity medical simulation as an assessment tool for critical thinking. The simulation environment, patient experience, and participant impressions were specific areas studied. To study these issues, an instrumental case study was developed using a single simulation case administered to 12 participants individually. Participants were selected from a purposeful sampling of the senior class. These participants played the role of the health care provider (physician) unsupervised. This allowed the participant to depend on and integrate their acquired knowledge, skills, and behaviors in the care of this simulated patient.

The simulation patient case was a 63-year-old male who presented to the emergency department complaining he did not feel well. His initial vital signs showed hypotension, tachycardia, and fever. The history the patient provided included a fever and productive cough at home. His physical examination had crackles in the right lung. The participants were allowed to ask questions of the mannequin. A script was followed to assure the same answers were given to each participant. The participants managed the patient which, depending on the course the participant undertook, consisted of fluid hydration, administration of oxygen, diagnostic testing and review, administering appropriate medication, recognizing the need for invasive procedures and CPR, and disposition. At the conclusion of the case, the participant completed a written note detailing the history and physical examination as well as medical decision making. They

also presented the same case to a physician. They were then asked questions to reflect on the case and the environment of simulation.

The simulation setting provided an environment that mimicked real-life scenario. The room, monitoring devices, and equipment resembled the resuscitation areas in the hospital. Each participant had a nurse in the room and a pharmacist available by phone. A drawback was the simulation mannequin which could not mimic facial expressions as a human could. The pace of the simulation case also is a weakness. Most cases were completed within 30 minutes, whereas in a real situation, management of this type of patient presentation takes more than 2 hours.

Because this patient experience allowed the participant to depend on his own knowledge and skills in an environment that mimicked the patient care area, it was immersive. Nowhere in medical education is a student allowed to manage patient care without supervision. In addition, supervision is a requirement of accreditation standards. Since this case was not a small group activity as with most simulation cases, participants could not depend on each other for answers, but rather it was their knowledge, skills, attitudes, and behavior that was showcased. The written note and oral presentation was from their individual patient encounter, as it is with licensed, practicing physicians. These items reflected the integration of the participant's fact gathering from the patient, data from the monitor and physical examination, and response to their interventions. This coalescence was the basis of the assessment of the critical thinking skills of the participant.

## Discussion

### Simulation Assessment Environment

Several participants indicated the simulation session felt unreal or the mannequin appearance was unhuman. The mannequin cannot provide facial expressions or body language to cue the participants. Also, the stiffness of the silicone skin at times produced an unrealistic feel or sounds during the physical examination. Another comment about the simulation environment is the rapidity of the change in patient condition. Although the participants completed the patient care portion within 30 minutes, this case would normally take several hours to manage. The participants were forced to make decisions quickly as well. It did provide them an environment to care for a critically ill patient, without the risk of harm, though. Students felt safe they would not cause harm.

This study allowed students to be the primary care provider instead of being observers of care being provided to a critically ill patient; thus, they were immersed in the case as the physician in charge. They were required to demonstrate required critical thinking skills: comprehension, acquiring, analysis, evaluating, and application. Several participants commented this was the first time they completed a simulation case by themselves. The participants were dependent on their own knowledge. They did not have other learners in the room to consult for solutions. The environment had the same monitors, sounds, and equipment as an intensive care unit or emergency department resuscitation room.

In the area of comprehension, did they understand the patient's problem? Assessment of this area looked at the participant's ability to obtain information from the patient. The information obtained reflected the patient's reason for being in the

emergency department and was focused to the evolving differential diagnosis the participant had developed.

Acquiring information from other sources based on the differential diagnosis was also another aspect that was assessed in the case. The physical examination and vital signs prompted most participants to immediately intervene. Based on the timeline, all participants paused to review the abnormalities identified in these areas. Based on the differential diagnosis and physical examination findings, most participants ordered the necessary labs.

Another aspect of assessment is analysis of the patient issues by the participant. Did the participant define key components within the context of the patient's problem(s) and differential diagnosis? Recognizing the abnormalities in the acquiring area is important, but intervening with the appropriate initial interventions are important in assure the patient does not have an adverse outcome. Intravenous (IV) hydration, administration of oxygen, and administration of appropriate antibiotics were important. Participants whose cases ended in "death" failed to administer IV hydration, oxygen, and antibiotics.

Evaluating represents the integration of knowledge and expertise for decision-making. The participants continued assessment of the patient to determine his response to their intervention(s). When the patient was not responding as expected, most participants continued with the treatment modalities and continued reassessment. The participants, whose cases ended in "death," struggled to reassess and determine appropriate interventions.

The last area of assessment in this case, is application. This area allowed

participants to be assessed for recognizing resources and appropriate life-saving measures such as central venous line and intubation. This also included the admission to the intensive care unit (ICU) and the correct diagnosis.

Critical thinking for this study was defined as a complex process or skill or ability, integrating knowledge and expertise to solve patient problems and achieve safe and effective patient care. The comprehension and acquiring areas do not require complex critical thinking skills, but analysis, evaluating and application do require the integration of knowledge and expertise in increasing fashion. These areas assess critical thinking to the greatest degree based on Bloom's and Krathwohl's work.

As part of the assessment, it was important the participant be immersed in the environment. It did not matter the time was sped up or the mannequin appeared unhuman. It was the immersion in the case that allowed for assessment. The five levels of assessment of critical thinking were addressed in the immersion. (Bloom, 1959) At the time of the implementation of this study, no literature was found supporting simulation as an assessment tool for critical thinking in medical students. There were studies (Deering, 2013; Marcario 2014; Murray, Boulet, Avidan, Kras, Henrichs, Woodhouse, & Evers, 2007) to support simulation as skills assessment tool in residency.

The implications from this study show regardless of the physical simulation setting, it allows for an equivalent experience as a supervising physician in the ICU or emergency room setting.

Summative Patient Experience

This case allowed the participants to complete the entire process of patient care, which includes written and oral communication of their care and activities that transpired

during the case. Using the same rubric these two patient care activities were evaluated. The written note and oral presentations contained items needed to score either "meets expectation" or "above expectation," but they were disorganized. Several notes were missing key information such as documentation of interventions (medications and procedures) participants completed, the need for CPR, and results of diagnostic data and the participant interpretation of them. A few written notes did not contain a diagnosis.

Based on the written documentation and oral presentation, the continued care of the patient in the ICU, would have been suboptimal. Assessment of medical student patient care currently is a snapshot in time, where they are not directly observed completing the case from an initial encounter to admission. It is an observation completed in a short period of time. The simulated patient experience, as an assessment tool, identified holes in knowledge, skills, and behaviors of all participants in providing patient care.

Research, thus far, shows simulation to be effective in assessing knowledge and skills (Rogers, 2004; Swing, 2002). This study provides support for utilizing medical simulation in assessing critical thinking skills as a culmination of student's ability to integrate knowledge about the patient illness, develop a care plan while caring for the patient, and implementing this plan or adjusting the plan in accordance to the data obtained in real-time. Simulation places the student in the role of health care provider, instead of learner. Although the recommendation has been to teach critical thinking in residency, this study supports the need for this to occur earlier (Harasym et al., 2008).

<div align="center">Thought Sequence</div>

The thought process sequence is to identify key historical features in a

conversation with the patient (comprehension), followed by a focused examination and obtaining relevant diagnostic data (acquiring). This is followed by interpretation of the available data (analysis) and continued assessment of the patient response and adjusting the plan (evaluating). The final step is recognizing resources and life-saving interventions (application) for the specific diagnosis.

There was a lack of depth to the participant thought sequence. I was dismayed at this finding. Participants were adept at obtaining information from the patient and requesting data, but they could not succinctly identify what the key factors and interventions were in the case. Every participant focused on a single component, the vital signs on the monitor. They had to be cued into reassessing the patient. Several students had prompting from the patient stating "I don't feel well" several times, before reassessing. Instead of looking at how the patient was doing, they were focused on the numbers being presented.

Prior to this study, there was no supporting evidence linking the thought sequence of critical thinking to using simulation in an assessment setting. Senior medical students are the level of Novice where they are rule governed, respond to external reward systems, and recognize common situational aspects of patient cases. (Dreyfus and Dreyfus, 1980, Carraccio 2008) The students, participating in this study, confirmed Dreyfus' model in which senior medical students perform at the Novice level.

## Conclusions

High-fidelity medical simulation as an assessment tool provided the environment for students to manage a complex case ensuring patient safety, which allowed them to utilize their critical thinking skills. This environment also provided the summative patient

experience necessary for assessment of patient management skills, but also their oral and written communication abilities by the rubric created for this study.

Assessment Implications

The case was administered to senior medical students and contained a cohort from two graduating classes. The timing of the summative assessment for critical thinking should be at the end of the senior year. The students will have completed most of the required course work, which includes Emergency Medicine, Intensive Care and sub-Internship rotations. These rotations provide clinical experiences exposing the students to critically ill patients and the sub-Internship rotation allows them to function as the post-graduate year 1 level healthcare provider.

Although we teach students skills and knowledge necessary to care for patients in the preclinical phase of medical education, we do not provide ample opportunities for them to practice and apply these skills in the clinical phase. Although they are required to be observed during every junior clinical rotation, feedback regarding their written and oral documentation is marginal. It is time consuming, yet when feedback is not provided regarding the student's ability to integrate knowledge and skills, we graduate physicians who require further remediation in residency.

The written documentation and oral presentations, although showed lapses in the critical thinking, they were disorganized. Students are taught in the preclinical phase the structure of both these types of documentations, but there is a gap in what they learned and the product of this simulation experience.

The case also provides an avenue for self-assessment or reflection which is a powerful tool for growth and improvement of patient care skills. Deficits in foundational

knowledge and skills can be assessed and used for self-reflection. Students can complete the case and review it to determine where they may improve themselves, what types of resources they may need for improvement, and show progress with an individualized plan.

The rubric used for this study would serve as the summative assessment tool. Since it is based on the expected milestones for a student graduating from Loma Linda University School of Medicine, this would assure our graduates are prepared for post-graduate year 1. The videotape and note would be used for the self-assessment or reflection process. In addition, the debriefing session helps congeal items each student recognizes as requiring improvement, but also what the faculty reviewer determines as strengths and weaknesses for the student.

## Written Communication

The Affordable Care Act (ACA), signed into law in 2010 and implemented in 2013, instituted the meaningful use of electronic medical records (EMR) for written communication; the changes within the billing system implemented by the Centers for Medicare and Medicaid Services (n.d.) have posed an interesting issue for written documentation.

Manufacturers, in trying to meet the onerous requirements for billing and documentation, have made the written documentation software to be user friendly and customizable. The software can upload the information into the note from areas with the patient record, without a careful review by the physician. A template can be created for the written documentation, order sets created so with one click laboratory testing, imaging, and medications can be ordered based on the patient complaint. This has created

the physician "technician." Prompts regarding certain aspects of patient care are also part of the EMR, where the software can recognize patterns and recommend further testing or interventions based on practice guidelines. The physician thinking process is lessened, with the intention of increasing patient safety.

The use of EMR and order sets has diminished aspects of critical thinking for patient care related to analysis, application, and evaluation. Participants documented less information about critical aspects of the case and narrative analysis than they presented orally. There was a mismatch also in comparing the information obtained in the participant simulation encounter with information conveyed in the written documentation and oral presentation. Relying on the computer algorithms in real patient encounters takes away from participant's developing critical thinking skills needed to treat ill patients, but also to effectively communicate this in the written note.

## Recommendations

### Curricular Implications

We are teaching our students the needed clinical skills and knowledge in the preclinical years, but they are not getting the opportunity in the clinical years for practice and application. In this study, students' notes were disorganized and the oral presentations were not concise and did not convey the severity of the patient or the procedures completed.

Our preclinical science curriculum is organ-system based. During the first year, all organ-system instruction deals with the normal cycle and in the second year, abnormal. Currently, the written note, oral presentation, and critical thinking skills are taught and assessed in the Physical Diagnosis (first year) and Pathophysiology and

Applied Physical Diagnosis (second year) courses. The written note format is the SOAP: subjective, objective, assessment, and plan. This is a good foundation, but is no longer a valid format, based on the billing CMS requirements. I would recommend changes to the preclinical curriculum to develop the student's skills. The Physical Diagnosis course should incorporate CMS requirements for documentation and enhance the SOAP format.

The Pathophysiology and Applied Physical Diagnosis course also incorporates tools to teach and evaluate critical thinking. The laboratory uses objective structured clinical evaluations (OCSE), to teach and assess student's ability to generate a differential diagnosis, determine which laboratory testing and diagnostic imaging to obtain, and further enhance the SOAP note. I would recommend that after each note, the student write a small conclusion on the finding of the diagnostic data, tying it to the patient complaints or physical examination findings, to demonstrate the critical thinking skills, but also document the medical decision making. This would be assessed using a rubric. The oral presentation during this course should reflect less recall of facts and more higher-order synthesis with integration of diagnostic data. This will allow the student to delve deeper in to their knowledge to determine what information to report.

For the clinical years, students should be allowed more practice in refining the art of the note writing and oral presentation, showcasing their critical thinking ability, with frequent feedback. Each clinical course in the third year uses OSCEs for evaluation and teaching; this provides perfect opportunity for review of these skills. The endpoint will be this simulation case in the senior year as a capstone. These recommendations will also help in sequencing of the development of critical thinking skills from first to fourth year, as more clinical education is added to the student's education.

The School of Medicine has seen a declining trend in the evaluation of our graduates during the internship year, in the following categories: problem solving and synthesis, clinical judgment, and clinical skills. This case should be done early in the senior year with a reflection from the student on areas of improvement and repeated later in the senior year to show improvement. Also, a method to assure the written note and oral presentations are organized and coherent is important. This could be part of a remediation program prior to graduating medical students. If critical thinking is an issue, remediation would also include techniques to improve this skill.

Implications for Further Research

The next assessment system for medical education will be the entrustable professional activities (EPA). Further research will be needed to determine if simulation can be used as an assessment tool for EPAs. This will allow for transition into the residency milestones. I recommend a document such as an "EPA Performance Evaluation" be completed as part of the capstone case indicating the student has met or not met the individual EPA prior to graduation. This document will be available to the graduate medical educator upon graduation of the student.

**Closing Remarks**

High-fidelity medical simulation offered a safe and realistic environment for assessment of critical thinking skills in the care of the ill. This environment gave each participant the opportunity to function as the physician in charge. Through this role, simulation allowed identification of gaps in the participants' critical thinking skills and documentation. These identified gaps have led to recognition of weaknesses in our

curriculum. Through the use of simulation, critical thinking skills can be assessed and

strengthened through our four-year curriculum.

APPENDIX A

STUDENT CONSENT

LOMA LINDA UNIVERSITY

School of Medicine

*Department of Emergency Medicine*

**INFORMED CONSENT**
**V1.3**

*HIGH-FIDELITY MEDICAL SIMULATION TO ASSESS*

*CRITICAL THINKING IN SENIOR MEDICAL STUDENTS*

Lynda Daniel-Underwood, MD
Loma Linda University School of Medicine
Department of Emergency Medicine
11234 Anderson St., Room A108
Loma Linda, CA  92354
(909) 558-4344

## 1. WHY IS THIS STUDY BEING DONE?

The purpose of this study is to analyze how high-fidelity medical simulation performs as a tool for critical thinking skills in senior medical students.  The rationale for this study is that a simulated interaction between medical student and patient has the potential to contribute to the process of critical thinking. Learning more about how critical thinking is developed in medical students has the potential to contribute to improvements in medical school curriculum.

You are invited to participate in this research study because you are a senior medical student enrolled at Loma Linda University. You were randomly selected to participate in this project.

## 2. HOW MANY PEOPLE WILL TAKE PART IN THIS STUDY?

20 subjects are expected to participate in the study.

## 3. HOW LONG WILL THE STUDY GO ON?

Your participation in this study may last up to one day.

## 4. HOW WILL I BE INVOLVED?

You may participate if you are 18 years or older and actively enrolled in medical school at Loma Linda University.

Participation in this study involves the following:

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- Completing a session with a simulated patient. The session will take place in the LLU Simulation Center and it will be videotaped.
- Completing a post-session interview with Dr. Lynda Daniel-Underwood that will also be videotaped
- The brief meeting, simulation and post-session interview should take approximately two hours.

## 5. WHAT ARE THE REASONABLY FORESEEABLE RISKS OR DISCOMFORTS I MIGHT HAVE?

In the past, the videotapes from simulation sessions you participated in were not retained. The only risk that is different in this study is that the tape will be retained for analysis. We will label the tapes with a unique ID linked to your identity. To minimize the risk of disclosing your identity, the only file linking your identity to the ID will be retained by the PI and it will be destroyed after analysis is completed. You may also feel some pressure to participate because the request is coming from the Dean's office or you might feel that your performance in the simulation will be linked to your academic records. Your participation and performance will not be linked to academic records, nor will your willingness to participate generate any academic benefits other than additional practice working with standard patients. The PI will not know your name if you do not consent.

## 6. WILL THERE BE ANY BENEFIT TO ME OR OTHERS?

You may benefit from the additional practice in completing a history and physical with a simulated patient. We also expect to gain an improved understanding of strategies to encourage critical thinking among senior medical students using high-fidelity medical simulation.

## 7. WHAT ARE MY RIGHTS AS A SUBJECT?

Participation in this study is voluntary. Your decision whether or not to participate or withdraw at any time from the study will not affect your ongoing relationship to Loma Linda University and will not involve any penalty or loss of benefits to which you are otherwise entitled. If you decide not to participate after signing the consent or scheduling the simulation session, please contact the research staff as soon as possible.

## 8. HOW WILL INFORMATION ABOUT ME BE KEPT CONFIDENTIAL?

Efforts will be made to keep your personal information confidential. As explained above, all tapes will be labeled with a numerical ID to protect your identity. We cannot guarantee absolute confidentiality. You will not be identified by name in any publications describing the results of this study. No study information will be added to your academic record.

## 9. WILL I BE PAID TO PARTICIPATE IN THIS STUDY?

You will be given a $25 gift card upon completion of your simulation.

## 10. WILL STUDY STAFF RECEIVE PAYMENT?

The School of Medicine and Department of Emergency Medicine are providing support for this study, but the researchers are not receiving any additional benefit as a result of the study.

## 11. WHO DO I CALL IF I HAVE QUESTIONS?

Call 909-558-4647 or e-mail patientrelations@llu.edu for information and assistance with complaints or concerns about your rights in this study.

## 12. SUBJECT'S STATEMENT OF CONSENT

- I have read the contents of the consent form and have listened to the verbal explanation given by the investigator.
- My questions concerning this study have been answered to my satisfaction.
- Signing this consent document does not waive my rights nor does it release the investigators, institution or sponsors from their responsibilities.
- I may call Dr. Daniel-Underwood during routine office hours at (909) 558-4344 if I have additional questions or concerns.
- I hereby give voluntary consent to participate in this study.

I understand I will be given a copy of this consent form after signing it.


| | |
|---|---|
| Signature of Subject | Printed Name of Subject |


| | |
|---|---|
| Date | |


The information in this consent form and any other written information has been accurately explained to, and apparently understood by, the subject or the subject's legally authorized representative. Informed consent was freely given by the subject or the subject's legally authorized representative.

## 13. INVESTIGATOR'S STATEMENT

I have reviewed the contents of this consent form with the person signing above. I have explained potential risks and benefits of the study.


| | |
|---|---|
| Signature of Investigator | Printed Name of Investigator |


| |
|---|
| Date |

APPENDIX B

AAC&U CRITICAL THINKING VALUES RUBRIC

# CRITICAL THINKING VALUE RUBRIC

*for more information, please contact value@aacu.org*

**Definition**

Critical thinking is a habit of mind characterized by the comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating an opinion or conclusion.

*Evaluators are encouraged to assign a zero to any work sample or collection of work that does not meet benchmark (cell one) level performance.*

| | Capstone | Milestones | | Benchmark |
|---|---|---|---|---|
| | **4** | **3** | **2** | **1** |
| **Explanation of issues** | Issue/problem to be considered critically is stated clearly and described comprehensively, delivering all relevant information necessary for full understanding. | Issue/problem to be considered critically is stated, described, and clarified so that understanding is not seriously impeded by omissions. | Issue/problem to be considered critically is stated but description leaves some terms undefined, ambiguities unexplored, boundaries undetermined, and/or backgrounds unknown. | Issue/problem to be considered critically is stated without clarification or description. |
| **Evidence** *Selecting and using information to investigate a point of view or conclusion* | Information is taken from source(s) with enough interpretation/evaluation to develop a comprehensive analysis or synthesis. Viewpoints of experts are questioned thoroughly. | Information is taken from source(s) with enough interpretation/evaluation to develop a coherent analysis or synthesis. Viewpoints of experts are subject to questioning. | Information is taken from source(s) with some interpretation/evaluation, but not enough to develop a coherent analysis or synthesis. Viewpoints of experts are taken as mostly fact, with little questioning. | Information is taken from source(s) without any interpretation/evaluation. Viewpoints of experts are taken as fact, without question. |
| **Influence of context and assumptions** | Thoroughly (systematically and methodically) analyzes own and others' assumptions and carefully evaluates the relevance of contexts when presenting a position. | Identifies own and others' assumptions and several relevant contexts when presenting a position. | Questions some assumptions. Identifies several relevant contexts when presenting a position. May be more aware of others' assumptions than one's own (or vice versa). | Shows an emerging awareness of present assumptions (sometimes labels assertions as assumptions). Begins to identify some contexts when presenting a position. |
| **Student's position (perspective, thesis/hypothesis)** | Specific position (perspective, thesis/hypothesis) is imaginative, taking into account the complexities of an issue. Limits of position (perspective, thesis/hypothesis) are acknowledged. Others' points of view are synthesized within position (perspective, thesis/hypothesis). | Specific position (perspective, thesis/hypothesis) takes into account the complexities of an issue. Others' points of view are acknowledged within position (perspective, thesis/hypothesis). | Specific position (perspective, thesis/hypothesis) acknowledges different sides of an issue. | Specific position (perspective, thesis/hypothesis) is stated, but is simplistic and obvious. |
| **Conclusions and related outcomes (implications and consequences)** | Conclusions and related outcomes (consequences and implications) are logical and reflect student's informed evaluation and ability to place evidence and perspectives discussed in priority order. | Conclusion is logically tied to a range of information, including opposing viewpoints; related outcomes (consequences and implications) are identified clearly. | Conclusion is logically tied to information (because information is chosen to fit the desired conclusion); some related outcomes (consequences and implications) are identified clearly. | Conclusion is inconsistently tied to some of the information discussed; related outcomes (consequences and implications) are oversimplified. |

APPENDIX C

CRITICAL THINKING ASSESSMENT RUBRIC

REVISION VERSION 1

| AAC&U VALUES Critical Thinking Assessment Rubric (modified) | | | |
|---|---|---|---|
| | **Below Expectation** **1** | **Meets Expectation** **2** | **Above Expectation** **3** | **Scoring** |
| **Comprehension**: Understanding the patient problem(s) | • May or may not recognize patient's condition changing and takes no action • Problem identification needs broader focus • Does not consider alternative problems • Written note lacks pertinent information • Does not meet expectations for professional behaviors | • Explains issues • Poses vital questions • Identifies problems and formulates them clearly and precisely • Communicates questions effectively. Written note organized in logical sequence • Takes action when patient's condition (visual and monitor) changes • Treats patient with dignity, civility, and respect | • Intervenes to patient's changing clinical situation • Completes tasks necessary for patient improvement (e.g. CVL, intubation, ABG) | 1 Below expectation 2 Meets expectation 3 Above expectation |
| **Acquiring**: Gain new information based on differential diagnosis | • Orders inappropriate diagnostic tests • Frequently interrupts the patient • Fails to acknowledge information from team member. Misses noninvasive monitoring abnormalities | • Orders appropriate diagnostic tests • Allows patient to communicate his story. Uses information from other team members • Notices non-invasive monitoring abnormalities (learner looks at monitor) | • Adjusts diagnostic tests based on changing patient condition | 1 Below expectation 2 Meets expectation 3 Above expectation |
| **Analysis**: Defining key components within context of patient problem(s) and differential diagnosis | • Fails to respond to abnormal diagnostic results • Fails to recognize need for antibiotics • Written note and oral presentation lacks information from multiple sources (non-invasive monitoring, labs, imaging) | • Recognizes the need for antibiotics • Written note and oral presentation demonstrates determination of care plan based on available evidence • Uses diagnostic results to determine fitness of the differential diagnosis from multiple sources • Uses the EBM skills in determining credibility of individual information sources | • Prioritizes patient care according to diagnostic results • Orders the appropriate antibiotic | 1 Below expectation 2 Meets expectation 3 Above expectation |
| **Evaluating**: Integrating knowledge and expertise for decision-making | • Formulates inaccurate differential diagnosis • Fails to modify differential diagnosis based on diagnostic results | • Formulates a plausible differential diagnosis • Recognizes abnormal diagnostic results and links results to the differential diagnosis • Uses basic science principles to support patient care plan | • Presents varied approaches to patient care plan • Differential diagnosis substantiated with diagnostic tests and physical findings | 1 Below expectation 2 Meets expectation 3 Above expectation |
| **Application:** Safely and effectively solving problem | • Identifies but cannot perform skills needed for case management as determined by Clinical Years Skills Log • Does not wash hands or maintain sterile environment during procedures • Consultant conversation lacks detail for transition of care • Exhibits unprofessional behavior with consultant (inadequate information for transition of care and honesty) | • Communicates information to patient, nurses, and ancillary staff • Performs procedures necessary for case management listed in Clinical Years Skills Log • Identifies other appropriate procedures (CVL) • Obtains ICU consultation for admission • Provides accurate and thorough H&P • Provides necessary detail to consultant for transition of care • Addresses patient safety such as hand washing and sterile environment for procedures. Exhibits honesty in interactions and documentations with consultant | • Obtains feedback from nurse, ancillary staff, and patient • Maintains patient safety and satisfaction • Performs correctly procedures indicated by the case not listed in Clinical Years Skills Log | 1 Below expectation 2 Meets expectation 3 Above expectation |

APPENDIX D

CRITICAL THINKING ASSESSMENT RUBRIC

REVISION VERSION 2

## AAC&U VALUES Critical Thinking Assessment Rubric (modified for medical education)

| | Below Expectation 1 | Meets Expectation 2 | Above Expectation 3 | Scoring |
|---|---|---|---|---|
| **Comprehension**: understand patient problem(s) | Identifies problems and formulates them without clarification <br>• May or may not recognize patient's condition changing and takes no action <br>• Problem identification needs broader focus <br>• Does not consider alternative problems <br>• Written note lacks pertinent information <br>• Does not meet expectations for professional behaviors | Identifies problems and formulates them clearly and precisely <br>• Explains issues <br>• Poses vital questions <br>• Communicates questions effectively to patient. Written note organized in a logical sequence <br>• Takes action when patient's condition (visual and monitor) changes <br>• Treats patient with dignity, civility, and respect | Must meet expectation and in addition: <br>• Intervenes to patient's changing clinical situation <br>• Identifies tasks necessary for patient improvement (CVL, intubation, ABG) | 1 Below expectation <br><br> 2 Meets expectation <br><br> 3 Above expectation |
| **Acquiring**: gain new information based on differential diagnosis | Fails to gather appropriate information <br>• Orders inappropriate diagnostic tests <br>• Frequently interrupts the patient <br>• Fails to acknowledge information from team member <br>• Misses noninvasive monitoring abnormalities | Gathers information from appropriate sources <br>• Orders appropriate diagnostic tests <br>• Allows patient to communicate his/her story. <br>• Uses information from other team members <br>• Notices non-invasive monitoring abnormalities (learner looks up at the monitor) | Must meet expectation and in addition: <br>• Adjusts diagnostic tests based on changing patient condition | 1 Below expectation <br><br> 2 Meets expectation <br><br> 3 Above expectation |
| **Analysis**: define key components within context of patient problem(s) and differential diagnosis | Fails to demonstrate determination of care plan based on available evidence <br>• Fails to respond to abnormal diagnostic results <br>• Fails to recognize need for antibiotics <br>• Written note and oral presentation lacks information from multiple sources (non-invasive monitoring, labs, imaging) | Demonstrates determination of care plan based on available evidence <br>• Recognizes need for antibiotics <br>• Written note and oral presentation demonstrate determination of care plan based on available evidence <br>• Uses diagnostic results to determine fitness of differential diagnosis from multiple sources <br>• Uses the EBM skills in determining credibility of individual information sources | Must meet expectation and in addition <br>• Prioritizes patient care according to diagnostic results <br>• Orders appropriate antibiotic | 1 Below expectation <br><br> 2 Meets expectation <br><br> 3 Above expectation |
| **Evaluating**: integrate knowledge and expertise for decision-making | Takes a simplistic approach to the patient problem <br>• Formulates an inaccurate differential diagnosis <br>• Fails to modify differential diagnosis based on diagnostic results | Takes into account the complexities of the patient problem <br>• Formulates a plausible differential diagnosis <br>• Recognizes abnormal diagnostic results and links results to differential diagnosis <br>• Uses basic science principles to support patient care plan | Must meet expectation and in addition <br>• Presents varied approaches to patient care plan <br>• Substantiates differential diagnosis with diagnostic tests and physical findings | 1 Below expectation <br><br> 2 Meets expectation <br><br> 3 Above expectation |
| **Application**: solve problem safely and effectively | Resolves the patient's problem(s) unsafely and ineffectively or fails to resolve the problem <br>• Identifies skills but cannot perform skills needed for case management as determined by Clinical Years Skills Log <br>• Does not wash hands or maintain sterile environment during procedures <br>• Consultant conversation lacks detail for transition of care <br>• Exhibits unprofessional behavior with consultant (inadequate information for transition of care and honesty) | Resolves the patient's problem(s) safely and effectively <br>• Communicates information to patient, nurses, and ancillary staff <br>• Performs procedures necessary for case management listed in Clinical Years Skills Log <br>• Identifies other appropriate procedures (CVL) <br>• Obtains ICU consultation for admission <br>• Provides accurate and thorough H&P <br>• Provides necessary detail to consultant for transition of care <br>• Addresses patient safety such as hand washing and sterile environment for procedures. Exhibits honesty in interactions and documentations with consultant | Must meet expectation and in addition <br>• Obtains feedback from nurse, ancillary staff, and patient <br>• Maintains patient safety and satisfaction <br>• Correctly performs procedures indicated by case not listed in the Clinical Years Skills Log | 1 Below expectation <br><br> 2 Meets expectation <br><br> 3 Above expectation |

APPENDIX E

THEMES

THEMES

Chief complaint

Review of system

       Positive noted for shortness of breath

       Positive noted for fever

       Positive noted for malaise

Past Medical History

       Hypertension

       Diabetes

       Coronary artery disease

Social History

Vital signs noted as abnormal

Diagnostic Data obtained

       Lactate level

       Hemoglobin

       Blood cultures

       Chest radiograph

Antibiotic administered

Identified need for central venous pressure and $ScvO_2$ monitoring

Central venous line placement

       Washed hands

       Chlorhexidine preparation of line insertion site

       Sterile field achieved before line insertion

       Obtained post-line placement chest radiograph

Identified need for intubation

Endotracheal intubation

      Equipment checked prior to intubation

      Cross-finger method during intubation

      Visible chest rise observed after intubation

      Obtained post-intubation chest radiograph

Fluid bolus ordered

Vasopressor ordered for MAP <65, refractory to fluids

Blood transfusion ordered for hemoglobin <10 g/dl and $ScvO_2$

Dobutamine ordered for $ScvO_2$ <70% (after optimal CVP, MAP, hemoglobin reached)

Repeated lactate

APPENDIX F

FINAL RUBRIC

| AAC&U VALUES Critical Thinking Assessment Rubric (modified for medical education) | | | |
|---|---|---|---|
| | **Below Expectation**<br>**1** | **Meets Expectation**<br>**2** | **Above Expectation**<br>**3** | **Scoring** |
| **Comprehension**: Understand patient problem(s) | Identifies problems and formulates them without clarification or broad focus | Identifies problems and formulates them clearly and precisely | Identifies problems and formulates them clearly and precisely<br>Intervenes to a dynamic patient condition | 1 Below expectation<br><br>2 Meets expectation<br><br>3 Above expectation |
| **Acquiring**: Gain new information based on differential diagnosis | Fails to gather appropriate information from various sources | Gathers information from appropriate sources and recognizes abnormalities | Gathers information from appropriate sources, recognizes abnormalities, and adjusts behavior to these abnormalities | 1 Below expectation<br><br>2 Meets expectation<br><br>3 Above expectation |
| **Analysis**: Define key components within context of patient problem(s) and differential diagnosis | Fails to demonstrate determination of care plan based on available evidence | Establishes care plan based on available evidence and supports the care plan on EBM skills | Establishes care plan based on available evidence and supports the care plan on EBM skills with priority for key interventions | 1 Below expectation<br><br>2 Meets expectation<br><br>3 Above expectation |
| **Evaluating**: Integrate knowledge and expertise for decision-making | Takes a simplistic approach to the patient problem | Takes into account the complexities or abnormalities of the patient problem and uses prior knowledge to support the care plan | Takes into account the complexities or abnormalities of the patient problem and uses prior knowledge to support the care plan<br><br>Substantiates differential diagnosis with diagnostic tests and physical findings | 1 Below expectation<br><br>2 Meets expectation<br><br>3 Above expectation |
| **Application**: Solve problem safely and effectively | Resolves the patient's problem(s) unsafely and ineffectively or fails to resolve the problem<br><br>Exhibits ineffective communication to staff | Resolves the patient's problem(s) safely and performs procedures listed in the Clinical Years Skills Log<br><br>Exhibits effective communication to staff | Resolves the patient's problem(s) safely, performs procedures listed in the Clinical Years Skills Log, and effectively communicates to staff<br><br>Recognizes the need for procedures indicated by the case not listed in the Clinical Years Skills Log | 1 Below expectation<br><br>2 Meets expectation<br><br>3 Above expectation |

APPENDIX G

CODES FOR RUBRIC DIMENSION

## CODES FOR RUBRIC DIMENSION

**Comprehension—Understand the patient's problem** (Conversation with the patient)
      Chief complaint
      History
      Review of systems
      Past Medical History
      Social history (smoking)

**Acquiring—Gain new information based on differential diagnosis** (Gathering the facts)
      Physical Examination
      Vital signs
      Diagnostic data-ordered
      Diagnostic data—laboratory tests reviewed
      Diagnostic data—chest x-ray reviewed

**Analysis—Define key components within context of patient problems(s) and differential diagnosis** (Appropriate initial interventions)
      Fluid bolus administered
      Oxygen given to the patient
      Antibiotics administered

**Evaluating—Integrate knowledge and expertise for decision-making** (Continued assessment of the patient response and planning)
      Vasopressor administered
      Intubation completed
      CPR initiated appropriately

**Application—Solve problem safely and effectively** (Recognizing resources and appropriate lifesaving intervention for the disease)
      Intensive care admission/"death"
      Pharmacy consult
      Recognizing the need for central venous line/intubation
      Correct diagnosis

APPENDIX H

SIMULATED PATIENT SCRIPT

SIMULATED PATIENT SCRIPT

Chief complaint: "I have had a fever and cough. I don't feel well."

History of present illness: The patient has had a fever and cough for a few days, which has been worsening. He is in the emergency department because he does not feel well. The cough is productive, but he cannot recall what color the sputum is because he swallows it. It does have a foul taste. He reports having a tactile fever, fatigue (generalized weakness) shortness of breath, productive cough, and chest pain only when he coughs, but denies having abdominal pain, nausea, vomiting or diarrhea, night sweats, weight loss, dysuria, frequency of urination, headache, numbness or weakness.

Past Medical History: Hypertension, Diabetes, Emphysema

Past Surgical History: None

Social History: Smoker just stopped a few days ago. He is not a drug or alcohol abuser.

Family History: Diabetes, Hypertension

If the participant recognizes the hypotension and tachycardia on the patient's initial vital signs and starts intravenous hydration with normal saline or lactated ringers, the blood pressure improves. They should recognize the potential diagnosis of pneumonia and start antibiotics. If they continue to administer intravenous hydration, the patient does not complain "I do not feel well." The systolic blood pressure improves to 90-95 mm Hg.

If the participant does not adequately intervene based on the initial hypotension and tachycardia, the patient worsens. He begins to persistently complain he does not feel good when the systolic blood pressure starts to drop from 75 mm Hg, and persists his complaint, until it reaches 55mm Hg. At this point he becomes unresponsive, if no resuscitative interventions are started. The nurse attempts to wake the patient, but is unable. There is a "thready" pulse. If the participant does not start resuscitative interventions, particular vasopressors, the patient loses his pulse and a code blue is started. If the participant starts resuscitative interventions, particular vasopressors, the patient has return of spontaneous circulation.

APPENDIX I

INTERVIEW QUESTIONS

INTERVIEW QUESTIONS

1. What was your thought sequence that led to the differential diagnosis?

2. What was your thought sequence that led to final impression?

3. What was your thought sequence that led to disposition?

4. What were your perceptions of the simulation during this case?

5. What has been your experience with simulation in medical school?

APPENDIX J

BRIEFING SCRIPT

BRIEFING SCRIPT

Thank you for your participation in the critical care simulation.

**INTRODUCTION TO THE CASE:** You will be given a chart, just like you would on your Emergency Medicine rotation. You are responsible for managing the entire case, like you would if you were they physician on the case. You will have a nurse in the room with you and pharmacist available by phone.

Treat the simulation mannequin just like you would a patient. You may speak to the mannequin by the name that is listed in the chart. Remember the patient care area is just like you would find it in the Emergency Department. I know you will be nervous, but you have been given the best education and I have confidence in your skills.

**DATA**: If you request labs or x-rays, these will be given to you when they are available.

**PROCEDURES**: You will be required to perform any procedures that are listed in the "Red Book" that you feel the patient requires. If you are unsure how to perform the procedure, just say "I would do ………… right now." If you feel the patient requires a procedure that is not listed in the "Red Book", just use the same phrase "I would do ……….. right now.  I do not know the steps for this procedure."  If you know the steps of the procedure, but are unable to actually perform them, state "I would do ………. right now. I know the steps of the procedure. They are ………….."  If you need other results/data that are not readily available, just ask for it.

The mannequin does have capacity for several procedures to be completed:  intubation, needle thoracotomy, Foley catheters. There are certain procedures that require another mannequin: central line placement, ultrasound.

**MEDICATIONS**: You will be responsible for recognizing the need for medications. If you are unsure of the dosage, state "The patient needs ………… I do not know the dosage." You may ask for a pharmacist consult.

**DOCUMENTATION**:  You will be asked to write a chart for the patient. A template will be given to you to follow, like charts in the Emergency Department. Be as complete as you can, remember this is a story of what happened in your case. There will be an order sheet included, so you can write the orders for the medications, testing or any other intervention that requires an order. You will also be asked to present the patient to the attending once you are done with the written documentation.

**COMPLETION**: At the end of the case, you will be asked to answer 1-2 questions regarding the case.

**VIDEOTAPING**: All aspects of the case will be taped for data collection. These will be destroyed after the dissertation is completed and defended.

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1999-Present  Clerkship Director, Emergency Medicine, Loma Linda University,
School of Medicine

**Professional Experience:**
1997-Present  Emergency Physician, Loma Linda University, School of Medicine
1994-1997    Major, United States Air Force, Medical Corpse, 81st Medical Group

**Awards:**
2013  CDEM Clerkship Director of the Year
2010  Departmental Advising Award, Loma Linda University, School of Medicine
2010  Alpha Omega Alpha
2007  Pi Lambda Theta
2007  Loma Linda University Adventist Health Sciences Center Wholeness Service
1997  Air Force Commendation Medal for Meritorious Service in Emergency
Medicine