Simulation-based learning is an emerging learning modality with promising potential for certified nurse-midwife (CNM) and certified midwife (CM) education. Unlike standard didactic methods, simulation-based learning affords opportunities to address multiple domains of learning and performance. Unlike standard clinical education, simulation-based learning provides learners exposure to events that are rare in the clinical setting, and allows learners to assume leadership roles in emergencies. Simulation-based learning is consistent with constructivist learning principles, which promote retention, understanding, and active use of skills. A simulation-based shoulder dystocia learning module was implemented on a pilot basis in a class of four student nurse-midwives. Student nurse-midwives self-assessed their preparedness to manage a shoulder dystocia in the cognitive, psychomotor, and affective domains before and after the simulation-based learning exercise. Feedback from student evaluations was promising. Although the small sample precluded statistical analysis, student self-assessment scores appeared to be higher after the simulation-based learning exercise. Open-ended student feedback was unanimous that simulation-based learning should be incorporated into the curriculum. Further implementation and evaluation of simulation-based learning in CNM and CM education is warranted. J Midwifery Womens Health 2007;52:492–498 © 2007 by the American College of Nurse-Midwives.

Keywords: clinical education, midwifery education, shoulder dystocia, simulation

INTRODUCTION

Midwifery educators must negotiate inherent conflicts between the needs of learners and realities of clinical practice. Although learners must be prepared to respond to crises and emergencies, these events are rare in training environments. When emergencies do occur, preceptors must step in and assume the leadership role in order to maintain optimal patient care. Therefore, students do not gain a lot of direct experience in managing crises, especially in the leadership role. Additionally, although health care is delivered by multidisciplinary teams, most education occurs within disciplinary boundaries. Finally, although errors in health care that compromise patient safety are most often tied to latent failures in teams and systems, the typical response to safety problems is staff education focused on individual skills and knowledge.

Responding to clinical crises and emergencies challenges the clinician in multiple domains of performance: cognitive, psychomotor, and affective. The cognitive domain includes the knowledge necessary for an effective response; the psychomotor domain includes the necessary skills. The ability to assume appropriate roles, manage one’s own stress responses, and maintain effective relationships with others are functions of the affective domain. Unfortunately, learning in the affective domain has been poorly addressed by standard approaches to clinician education.

The aviation industry was one of the first industries to systematically investigate the causes of accidents and critically assess its training methods. It was soon recognized that crew members’ failure to adequately manage their human resources in times of crisis was a major contributor to accidents. Training was revised to include flight simulators that reproduced challenges in cognitive, psychomotor, and affective domains of performance. Periodic simulation-based training is now mandated for commercial aviators.

More recently, leaders in medicine and nursing have begun to make similar appraisals of the causes of maloccurrences and to critically assess existing educational methods. In 2004, the Joint Commission on Accreditation of Healthcare Organizations conducted a root cause analysis of obstetric maloccurrences. In 72% of these cases, poor communication was identified as a causal factor, and in 55%, failure to function as a team was cited. Recommendations for perinatal areas included conducting team training and clinical simulation drills for high-risk events, such as shoulder dystocia, emergency cesarean delivery, maternal hemorrhage, and neonatal resuscitation.

In the United Kingdom, annual “skills drills” training is recommended jointly by the Royal College of Midwives and the Royal College of Obstetricians and Gyne-
cologists. Periodic drills are also a requirement of newly
implemented maternity risk management standards in the
United Kingdom.6 In Europe and the United States,
simulation-based learning has been implemented for
obstetric residents,7 trauma medicine and advanced car-
diac life support teams,8 and professionals involved in
neonatal resuscitation.4,8 –10 In addition to high-conse-
quence emergency situations, simulation-based learning
has been used to improve clinicians’ approaches to
sensitive issues, such as cultural conflicts,11 alcohol
abuse,12 problems experienced by the elderly,13 and
delivering bad news.14
The incorporation of simulation-based learning in
certified nurse-midwife (CNM) and certified midwife
(CM) education has potential advantages for educators,
students, and practicing professionals seeking continuing
education, and may ultimately benefit women receiving
midwifery care. The purpose of this article is to review
the basic concepts and applications of simulation-based
learning from a learning theories perspective and to
descibe a trial implementation of simulation-based
learning with nurse-midwifery students.

SIMULATION: A CONSTRUCTIVIST LEARNING APPROACH

According to the constructivist theoretical approach to
learning, learners require opportunities for concrete,
contextually meaningful experiences through which they
can search for patterns, raise questions, and model and
interpret their strategies and ideas.15 This approach to
learning contradicts many of the assumptions underlying
the standard methods of clinician education: that mean-
ning can be transmitted to learners via symbols; that
learners can incorporate teachers’ understandings for
their own use; and that concepts can be taught out of
context.15 In contrast, learning based on constructivist
principles promotes high-order learning outcomes that
are appropriate for professional education, such as inde-
pendent reasoning, critical thinking, problem solving,
and the ability to usefully deploy knowledge and act
based on understandings.16

Simulation-based learning is consistent with construc-
tivist principles. Removing learners from the classroom
and placing them in a simulated delivery room with a
patient, equipment, and support staff and a dynamic
scenario design challenges the learner in multiple do-
mains and provides concrete learning opportunities within
realistic contexts. Driscoll16 outlined conditions for opti-
mal learning based on a constructivist approach. Table 1
describes these conditions and the ways that simulation-
based learning can meet them. The complex, multidimi-
sional learning outcomes fostered by constructivist
approaches are ideally suited to prepare learners for the
challenges presented by clinical crises and emergencies.

Table 1. Optimal Learning Conditions Related to Simulation-Based Learning

<table>
<thead>
<tr>
<th>Condition for Learning</th>
<th>Application in Simulation-Based Learning</th>
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</table>
| Embedding learning in complex, realistic, and relevant environments | • Simulating complex demands of performance in the clinical environment  
• Designing scenarios that are relevant to challenges encountered in clinical practice  
• Allowing opportunities to experience a variety of rare clinical crises and emergencies |
| Supporting multiple perspectives and multiple modes of learning | • Incorporating cognitive, auditory, visual, and tactile modes of learning  
• Accommodating different learning styles |
| Providing for social negotiation as an integral part of learning | • Reproducing the social context of the clinical setting  
• Involving critical interactions and relationships with patients, staff, and colleagues  
• Encouraging collaboration among peers and instructors during debriefing to extract lessons from the simulation experience |
| Encouraging learners’ self-awareness of knowledge construction processes | • Promoting self-reflection on experience and performance through debriefing  
• Allowing identification of learning progress and continued needs by debriefing |

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Fidelity

Fidelity refers to the accuracy with which a simulation reproduces relevant characteristics of the clinical situation. High fidelity refers to simulations in which participants are able to “suspend disbelief” and behave as they would in the clinical setting. In some of the training literature, the term “fidelity” has been used synonymously with simulation, or represented as a unidimensional construct from high to low. This is unfortunate, because fidelity is a multidimensional construct, and different kinds of fidelity may be appropriate for different learning goals. Beaubien and Baker proposed a typology of fidelity including case studies, role plays, part task trainers, and full scale simulations. Figure 1 outlines the basic elements of these four types of simulation. A progressively increasing complexity is evidenced in the typology.

Although it is often desirable to reproduce relevant aspects of the task with high fidelity, this is not always the best course of action. The fidelity of various aspects of the simulation should be tailored to the learning goals of the exercise and the level of the participants. As training progresses and skill levels improve, additional task complexities and more dimensions of fidelity can be incrementally introduced.

One aspect of fidelity is environmental cues, defined as information accessible to participants through interactions with the simulation environment. Simulations are usually designed to present participants with an initial paucity of information. Participants should be able to explore the environment and obtain necessary information in the same manner that they would in the real clinical environment. Sophisticated simulation equipment can provide cues about patients’ conditions, but simple expedients, such as slowly tapping on a fetal monitor transducer to simulate fetal bradycardia, can provide effective environmental cues.

Roles

Simulation roles include the moderator and various participant roles. The moderator is an instructor who guides the simulation process as described below. During the simulation, the moderator may intervene to provide feedback or additional information. The moderator may also determine the outcomes of participant actions and operate any necessary equipment for the simulation. The moderator should be ready to provide support or assistance, but should “fade away” when such support is not needed. Moderators should resist the urge to intervene whenever participants make mistakes. Allowing learners to make mistakes and experience the consequences, unthinkable in the clinical setting, is considered an advantage of simulation-based learning. Participants play the various roles in the simulated clinical situation. For a simulation designed to meet learning needs of midwives, one participant will play the role of the midwife. Other participants may play the roles of nurses, physicians, support staff, the patient’s family, or anyone else who would be present in the clinical situation. The role of the patient may be played by a participant, a faculty member, or a simulated patient (an actor trained to play the role). Participants may rotate through the various roles to experience different perspectives on the clinical situation. An important function of the moderator is to encourage participants to “stay in their roles” during a simulation, and behave as they would in a real clinical situation.

Process

The simulation process consists of briefing, simulation, and debriefing. In the pre-simulation briefing, participants are familiarized with the environment, their roles, the patient history, and any other necessary background information in the scenario. Briefing may also include the learning objectives of the simulation. Desired outcomes or optimal behaviors can be reviewed to focus participants’ efforts during the simulation.

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Role Play</th>
<th>Part-Task Trainer</th>
<th>Full-Scale Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Reviews background, events, and outcomes</td>
<td>- Re-enacts interactions or events of interest</td>
<td>- Simulates one segment of a complex task</td>
<td>- Simulates a complex task in its entirety</td>
</tr>
<tr>
<td>- No attempt to re-enact events</td>
<td>- May use simulated patients (actors) to portray defined conditions or patient populations</td>
<td>- Most appropriate for developing psychomotor skills</td>
<td>- Includes all environmental complexities attendant to the task</td>
</tr>
<tr>
<td>- Appropriate for cognitive learning and developing attitudes</td>
<td>- Allows repeated practice so task performance becomes automatic and does not require conscious direction</td>
<td>- May reproduce elements of stress among participants</td>
<td>- Includes elements of teamwork and interactions between professionals of different disciplines</td>
</tr>
</tbody>
</table>

Figure 1. Typology of simulation fidelity derived from Beaubien and Baker. (Figure by C. Byrne).
The simulation is conducted according to a pre-planned scenario. The scenario stands in the same relation to a simulation as the script does to a play: the scenario outlines background history, participant roles, key events, and possible outcomes. Unlike a play, simulation scenarios are designed to be dynamic: the actions and decisions of participants will affect subsequent events. Scenarios should be designed to coincide with learning objectives and tested by expert participants before implementation. Some aspects of the scenario may be revealed to the participants during briefing, while others are left for participants to discover during the simulation.

After the simulation, a debriefing is conducted to identify and reinforce the lessons that have been learned. Some authors have identified debriefing as the most important part of the simulation process. Students and faculty benefit from opportunities to reflect on the simulation and provide feedback. Individual or team actions during the scenario are evaluated, effective practices reinforced, and alternatives suggested for less than optimal practice. Participants may need to discharge stress or emotions arising from the simulation events. It can be helpful to allow participants to describe their experiences before formulating evaluations. Some authors have noted the usefulness of video taping simulations for review during debriefing.

Issenberg et al. conducted a systematic review of the literature on simulation-based learning to identify the features of simulations that lead to effective learning. Providing feedback on the results of one’s performance was identified as the most important feature of simulation-based learning. Ideally, feedback is “built in” to the scenario design. For example, when a participant performs a shoulder dystocia maneuver incorrectly, resulting in failure to affect delivery, the participant has received feedback on his or her performance of the maneuver. Feedback can also be provided by instructors during the simulation or provided during debriefing.

ADVANTAGES OF ADVANCE PREPARATION
Simulation-based learning offers distinct advantages in professional clinical education. These include advance preparation for emergencies that occur rarely and practice to promote improved teamwork.

Training for Emergencies
Bourne and Yaroush synthesized the literature on cognitive performance in emergencies. Although their review focused on aviation, emergencies have common characteristics in any context. Emergencies are dynamic, because early actions determine the conditions in which subsequent decisions and actions must be made. They are time-dependent, because decisions and actions must be made in the correct temporal relationship to environmental demands. They are often complex, because numerous variables can interact in unpredictable ways. They are stressful because of the intense psychological and cognitive pressures on participants. They typically require a team response, which requires individuals to work together effectively. Responding to emergencies presents professionals with high cognitive workloads, during which attention often must be divided between different tasks or aspects of a complex task.

Training clinicians to manage emergencies effectively has been problematic. Traditional didactic methods of teaching, which focus primarily on the cognitive domain, poorly address the complex multidimensional nature of clinical emergencies as outlined above. Emergencies are rare events, so students have only rare or sporadic exposure to them in the course of clinical education. Simulation-based learning can provide repeated exposure to rare events in a learner-centered environment that can be made appropriately complex for the learner’s stage of training. Simulation-based learning also affords opportunities for learners to assume leadership roles that they could not assume in the clinical setting.

Training to improve performance under stress is particularly problematic. Cognitive responses to stress are highly variable and depend on individual traits, but degradation of performance resulting in ineffective responses is likely when high levels of stress are present. High-fidelity simulations are deliberately designed to reproduce stress responses in the simulation environment. Analysis of resident physicians’ heart rate variability demonstrated physiologic stress responses during neonatal resuscitation simulations, and stress levels increased when challenges were present in multiple domains of performance.

The effects of stress on performance can be ameliorated by repetitive practice, because skilled tasks that can be executed without conscious deliberation are more likely to succeed in an emergency. An aviation industry study found that the best performance was achieved in a three-phase training process in which the trainee: 1) learns the task in a stress-free situation; 2) experiences the stressor passively; and 3) practices the newly acquired skills under stress. Rehearsal of stress management techniques under conditions that induce stress has also been shown to ameliorate the negative effects.

Training for Teamwork
Poor communication and ineffective teamwork have been identified as root causes in the majority of clinical maloccurrences. Despite the fact that health care is delivered by multidisciplinary teams, health care training has traditionally focused on individual skills and remained segregated within professional disciplines. A major advantage afforded when
Table 2. Assessing Teamwork Behaviors

<table>
<thead>
<tr>
<th>Participant Behavior</th>
<th>Description</th>
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<tbody>
<tr>
<td>Leadership</td>
<td>Provides direction assertively to others</td>
</tr>
<tr>
<td></td>
<td>Supports team members</td>
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<tr>
<td></td>
<td>Assigns tasks to others</td>
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<td></td>
<td>Requests additional help when necessary</td>
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<tr>
<td>Follower-ship</td>
<td>Performs tasks as directed</td>
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<tr>
<td></td>
<td>Actively participates in team</td>
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<tr>
<td></td>
<td>Assumes appropriate responsibility</td>
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<tr>
<td></td>
<td>Requests help when necessary</td>
</tr>
<tr>
<td></td>
<td>Maintains proper balance between assertiveness and respect for authority</td>
</tr>
<tr>
<td>Communication</td>
<td>Exchanges information of optimal quantity and quality with team members</td>
</tr>
<tr>
<td></td>
<td>Shares assessments and intentions</td>
</tr>
<tr>
<td></td>
<td>Requests and provides clarification</td>
</tr>
<tr>
<td>Maintenance of</td>
<td>Shows respect for leaders and subordinates</td>
</tr>
<tr>
<td>interpersonal</td>
<td>Maintains professional behavior and demeanor</td>
</tr>
<tr>
<td>climate</td>
<td></td>
</tr>
<tr>
<td>Mutual monitoring</td>
<td>Observes closely to maintain awareness of ongoing processes</td>
</tr>
<tr>
<td></td>
<td>Assists and supports others</td>
</tr>
<tr>
<td></td>
<td>Informs team members of problems</td>
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<tr>
<td></td>
<td>Corrects errors</td>
</tr>
<tr>
<td>Workload management</td>
<td>Distributes workload appropriately among team members</td>
</tr>
<tr>
<td></td>
<td>Prioritizes tasks appropriately</td>
</tr>
<tr>
<td>Feedback</td>
<td>Provides high quality information in response to communications of others</td>
</tr>
<tr>
<td></td>
<td>Uses closed-loop technique to clearly convey message</td>
</tr>
<tr>
<td>Situation awareness</td>
<td>Perceives environmental cues</td>
</tr>
<tr>
<td></td>
<td>Anticipates possible outcomes</td>
</tr>
<tr>
<td></td>
<td>Remains alert and focused on priority tasks and information</td>
</tr>
<tr>
<td>Stress reduction</td>
<td>Employs strategies to reduce stress</td>
</tr>
<tr>
<td></td>
<td>Avoids behaviors that induce unnecessary stress in others</td>
</tr>
</tbody>
</table>

Data taken from Ostergaard et al., Healey et al., Hamman, and Halamek et al.

using simulation-based learning in health professionals’ education is the ability to incorporate the challenges of effective teamwork.

Effective team behaviors in responding to clinical emergencies include leadership and follower-ship, communication, maintaining an appropriate interpersonal climate, mutual monitoring, workload management, feedback, situation awareness, and stress reduction. In Table 2, descriptions of these functional teamwork behaviors are noted. These incorporate a variety of skills useful in clinical crises that can be assessed during simulation-based learning. These behaviors are best acquired and practiced in interdisciplinary simulations that incorporate both technical and teamwork skills.

Diversity of Learning Needs

Richardson detailed the diverse learning needs of students. Compared to previous cohorts, current nursing school students exhibit broader ranges of age and life experience, are generally older, and may have non-nursing degrees and employment experiences. Simulation-based learning can help students bridge the gap between classroom and clinical settings and support their ability to apply what they have learned.

Requirements of adult learners include the ability to build on their own experiences, learn material that is relevant to real-life situations, and take an active role in learning. Simulation-based learning is consistent with these requirements and is well-suited to meet the needs of adult midwifery students. Simulation-based learning can also accommodate diverse learning styles and teaching methods, allowing students to learn according to their own styles.

When students encounter difficulty applying classroom knowledge in the clinical setting and their performance is below standard, remediation is required. Haskvitz and Koop explored the use of simulation-based learning in clinical remediation. Rather than simply returning the student to the clinical setting with revised goals and increased supervision, they devised simulation scenarios to recreate the kinds of situations in which the student was experiencing difficulties. Given a safe, supportive, learner-centered environment in which to practice their skills, students were able to return to the clinical setting with increased confidence and improve their performance.

Pilot Implementation of Simulation-Based Learning

To explore the application of simulation-based learning to midwifery education, a shoulder dystocia learning module incorporating simulation was designed, implemented, and evaluated for second-year nurse-midwifery students. The module replaced the existing material on shoulder dystocia in the program’s intrapartum course. The collection, analysis, and reporting of student evaluation data from this module was reviewed and approved by the institution’s research review board.

Four second-year students were enrolled in the course and participated in the learning module. Learning activities included a didactic self-study presentation and a 2-hour simulation workshop. Before the workshop, students completed a self-assessment. This consisted of three Likert-type items, rating the students’ perceptions of their own preparedness to assume the CNM role in shoulder dystocia management. One item focused on the cognitive information, another on psychomotor skills, and a third on the affective dimension of role attainment. Open-ended student feedback was also elicited.

The workshop consisted of four iterations of briefing, simulation, and debriefing, so that each student
had an opportunity to play the CNM role once. A simulated labor and delivery room in a nursing school clinical laboratory was used to create the environment. The scenarios were designed to simulate increasingly difficult dystocias and more extensive maneuvers were required to effect delivery with each iteration. A Noelle™ (Gaumard Scientific Co., Inc., Miami, FL) birthing simulator, which includes full-body maternal and neonatal manikins, was used to simulate the mother and the baby. In each simulation, a faculty member provided the “voice” of the mother to enact provider–patient interactions. Other students and faculty played the roles of nurses, family members, and additional personnel, such as physicians and the neonatal team. Students were not graded on their performance in the simulations. During debriefing, participants were asked to describe their experiences and identify which actions and behaviors worked well, as well as possible improvements for the next iteration.

The workshop was well received by students and faculty. Evaluation feedback indicated that the students unanimously supported inclusion of simulation-based learning in the course curriculum. The small number of student participants precluded statistical analysis, but post-workshop self-assessment mean scores were higher on the psychomotor (pretest = 2.5; posttest = 4.25) and role attainment (pretest = 2.0; posttest = 4.25) items. Scores on the cognitive item increased minimally (pretest mean = 3.75; posttest mean = 4.25). Interpretation of these findings is limited because of the small sample size and the use of a non-validated instrument. However, the appearance of improvement in self-evaluation scores, and the students’ positive responses to the open-ended evaluation items, suggest that simulation-based learning is a promising instructional modality for midwifery students. Further trial and evaluation of the method is indicated.

**COST INFORMATION**

Equipment for full-scale simulations is expensive. The price of a basic Noelle™ maternal and neonatal simulator is more than $2500. More advanced models include computer-controlled interactive functions and may cost over $20,000. The simulator used for the trial implementation was one of the advanced models, but the faculty determined during pre-workshop testing of the simulation scenarios that the advanced features were not helpful for this exercise and they were not used.

The costs of simulation-based learning are not limited to equipment costs. Investments of time and effort by faculty to develop, implement, and evaluate a simulation-based learning program represent real costs and the use of scarce resources. Space must also be provided, which may require new construction or renovation of existing space. The emerging consensus in clinical education is that the learning enhancement and care improvement benefits of simulation-based learning are worth these costs.

**CONCLUSION**

Learning outcomes of simulation-based learning are consistent with core competencies as defined by the American College of Nurse-Midwives (ACNM). Skillful communication and collaboration with other members of the health care team are hallmarks of midwifery. Participation in activities that ensure and validate quality practice are among the professional responsibilities of CNMs and CMs. The skillful use of techniques for management of emergency complications and abnormal intrapartum events is a component of midwifery care. Initial learning and maintenance of these core competencies can be facilitated by simulation-based learning.

Simulation-based learning exemplifies a constructivist learning approach that promotes durable retention, understanding, and the active use of knowledge and skills. 

Implementation of effective simulation-based learning requires more than simply purchasing simulation equipment. Simulation-based learning should be integrated into the CNM/CM curriculum. Simulation-based learning programs can be developed with the same systematic assessment of learner needs, formulation of learning objectives, planning of learning activities, and evaluation of individual, course, and program outcomes that characterizes accredited midwifery education.

The trial implementation of simulation-based learning for CNM students described in this article produced promising results, but more study is needed to validate its use in midwifery education. Future studies could include objective measures of performance in addition to student self-assessment measures. Validated instruments and larger samples would also be helpful.

Simulation-based learning is consistent with national and international trends and professional standards for patient safety, multidisciplinary models of care, and quality care improvement. Preparing for effective multidisciplinary teamwork in emergencies, while educating diverse learners to meet the needs of patients, are major challenges for midwifery educators. Simulation-based learning is a promising educational methodology with great potential to help meet these challenges. Further exploration and implementation of simulation-based learning is warranted.
REFERENCES


