

Utilization of a Blended Learning Approach to Teach Pediatric Resuscitation to Medical Residents

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Abstract

Because of the rarity of the event of pediatric resuscitations, residents are not able to practice and maintain skills that are critical for caring for these patients. Training must be focused on rapid decision making, identification of anatomical structures for intubation, selecting appropriate equipment and sizes for resuscitation procedures, selection of appropriate medications and leading a team in stressful situations. The goal of this study was to evaluate the ability of a blended learning approach to facilitate the acquisition and retention of pediatric resuscitation skills utilizing both simulation technology and on-line education resources.

Keywords

Blended Learning Curriculum, Pediatric Resuscitation, Simulation, Emergency Medicine

1. Introduction

Residents often express a lack of knowledge, lack of confidence and a feeling of anxiety when it comes to managing critically ill pediatric patients (Langhan, Keshavarz, & Richardson, 2004) and specifically have concerns for their abilities to perform a successful pediatric resuscitation. There have been multiple studies suggest that residents are frequently unsuccessful in resuscitation procedures such as pediatric intubations (Downes, Narendran, Meinen-Derr, McClanahan, & Akinbi, 2012; Falck, Escobedo, Baillargeon, Villard, & Gunkel, 2003). One of the reasons for the lack of success is the infrequency at which the residents are exposed to critically ill patients and given the opportunity to perform lifesaving procedures and made decisions in a high intensity critical situation (Langhan, Keshavarz, & Richardson, 2004; Chen, Cho, Shofer, Mills, & Baren, 2007). Resuscitat-

ing a patient is an incredibly complex cognitive task. A resident must perform the task in a very defined step-wise fashion, but at the same time be able to trouble-shoot problems that arise, integrate individual patient factors and incorporate environmental stimuli and information while performing the resuscitations, often in a life or death situation. While the success rate of pediatric resuscitations by residents has never been studied at our particular institution, similar concerns have been expressed by both faculty and residents concerning the confidence and competence of residents of pediatric resuscitations performed by residents. Because of the rarity of the event of pediatric resuscitations, residents are not able to practice and maintain skills that are critical for caring for these patients. Training must be focused on rapid decision making, identification of anatomical structures for intubation and selecting appropriate equipment and sizes for resuscitation procedures.

The goal of this study was to evaluate the feasibility of utilizing a blended learning approach to facilitate the acquisition and retention of pediatric resuscitation skills enabling pediatric and emergency medicine residents to become successful, competent, confident, and skilled at pediatric resuscitations.

The educational setting was in a large academic hospital in the United States. Medical residents and medical students are educated during their various clinical rotations including their rotation in the pediatric emergency department. The teaching environment includes formal structured teaching time as well as informal education that the residents and students receive while they are working their clinical shifts in the pediatric emergency department. Medical students are trained in basic physiology and pathology of both pediatric and adult patients, but the emphasis is primarily on adult patients. Most of their rotations in medical school occur in adult settings. Therefore, for medical students and residents, the pediatric experience is extremely limited and they may never take care of critically ill children, unless they chose to do an elective in an area such as the pediatric critical care unit or the pediatric emergency department. Treating pediatric patients is a very different experience from that of adults due to a variety of reasons, they have different physiology, require different medications, and they suffer from different disease processes and the presence of family members/parents during the resuscitation add to the level of stress for the residents and students. Medical residents receive very little structured training on pediatric resuscitation. Consequently, the residents do not get the opportunity to learn or practice their skills on pediatric patients very often. It is imperative that residents learn to take care of critically ill pediatric patients and specifically performing pediatric resuscitations. The emergency department possesses high-fidelity training mannequins, used for educational training. These mannequins are capable of simulated patient physiology, including breathing, heart sounds and lung sounds, seizure like activity and vital signs. The simulated patient includes a specific scenario in which residents are allowed to work through a variety of disease process and perform procedures, just as they would on a real patient. True learning occurs when the learner is able to coordinate and integrate the skills and knowledge that they have acquired and transfer that knowledge to new situations. Residents must be stimulated in a variety of ways that reach all the senses and allow the brain to relate new material to past experiences. One way that we can achieve this level of learning is to utilize blended learning environments that provide both structured and self-directed, self-paced learning to adapt to the individual learning styles of each resident.

2. Participants

Participants in this study were first, second and third year pediatric and emergency medicine residents. There are a total of 49 pediatric residents and 24 emergency medicine residents in our hospital. 8 residents participated in our study during their 4-week rotation in the pediatric emergency department.

General participant characteristics:

- Age: 25 - 48 years old;
- Gender:
 - Pediatric residents: 80% female, 20% male;
 - Emergency medicine residents: 37% female, 63% male;
- Advanced degree education-doctor of medicine (M.D.) or doctor of osteopathic medicine (D.O.);
- 88% of residents graduated from an American Medical school; 12% are Foreign Medical graduates;
- 2 of the pediatric residents completed an entire residency in another country and practiced as physicians prior to coming to the United States;
- Work experience varied depending on residents' previous background. May have as little as 1 day experience to several years of medical experience, most resident experience will range from 0 - 3 years.

Residents were eager to improve their resuscitation skills; however some residents were hesitant to participate in simulation environments. Their reluctance usually stemmed from limited training and experience, the difficulty of making rapid decisions in a stressful environment due to being unsure of themselves and prior experiences of poor outcomes in resuscitations in which they have participated.

The residents are considered adult learners, a special population of learners. The residents come from a wide variety of cultural and ethnic backgrounds. They have had previous work experience that they were able to draw from as they completed the learning module. The residents were experienced using computers, smart phones and tablets to access medical information and utilizing medical based applications. Residents had access to computers and tablets provided by the hospital and the majority of residents also own smartphones. The residents also had some experience participating in simulated patient training. Simulated patients and mannequins are used for educational purposes in medical school so even first year residents had experience with simulation. Some residents had previous work experiences as RNs, EMTs, and even have been attending physicians in other countries prior to moving to the United States. They are self-motivated and independent learners.

3. Study Design

3.1. Research Paradigm

Blended learning techniques are common in today's academic environments however this form of education is seldom utilized in medical education. Blended learning has been described as a purposeful, open and disciplined strategy that utilizes multiple approaches including face-to-face methods as well as online technologies to meet the needs of a wide range of students (Picciano, 2009: p. 7), (Garrison & Vaughan, 2008). Blended learning focuses on an inquiry processes that ensure core concepts are constructed and assimilated in a deep and meaningful manner. These processes do not occur in a single learner silo but rather in the formation of an educational community in which collaboration and social interaction play key roles in allowing learners to examine, discuss, explore and reflect on their learning experience. For that reason, a blended learning approach was chosen by the author to evaluate its feasibility as a potential instructional technique in the emergency department.

3.2. Educational Unit Plan Overview

This educational module consisted of two components that were completed during the 4-week course of their pediatric emergency medicine rotation. The first component of the education module consisted of in-situ simulation training. Simulations were designed to focus on resuscitation knowledge and skills. The simulations served to develop fundamental knowledge and procedural skill training. The residents were taught airway anatomy, rapid sequence medications and dosing, resuscitation medications, CPR and intubation skills via on-line teaching. Residents were required to participate in the simulations as team leader as well as members of the medical team. The second component was web-based learning. Residents were able to augment the simulation experience with web based modules and case studies that allowed residents with different learning styles to acquire the necessary information. The on-line material contained rapid reference material, resuscitation medication pharmacology, self-assessment quizzes, pediatric airway anatomy and case-based learning exercises. These materials were available for the entire duration of the educational module as well as after the completion of their rotation to allow them to refresh their memory. For the purposes of data collection we utilized three sources of data. Prior to starting the course, the residents completed a pre-course self-assessment and a pre-test. At the completion of the course, the residents completed a post-course self-assessment, a post-test. There was also an objective form filled out by an attending physician during simulation training.

3.3. Simulation Training

The in-situ simulations were conducted in the resuscitation room of the pediatric emergency departments. The residents participated in a total of 4 simulations (once a week). The residents participated in small groups of 2 - 4 residents. The groups were mixed with first, second and third year residents. This allowed residents to learn from each other and provide a variety of experiences from resident perspective for discussion of topics. Residents practiced resuscitation procedure skills, such as intubation, and decision making processes through hands-on high fidelity in-situ training. Oral and written feedback occurred in directed debriefing after each hands-on scenario or simulation. The debriefing allowed students to self-assess and note areas for improvement

as well as instructors to comment on positives and areas needing improvement. This feedback occurred immediately, which allowed residents to internalize the impact and importance of their performance.

Example of Simulated Case Scenario

Case: 8-day-old twin 38-week gestation with increased work of breathing and poor feeding for 1 day. She had 3 episodes of vomiting prior to arrival and now refusing to breastfeed. Parents report no fever.

Physical Exam: Ill appearing infant with tachypnea and retractions; poor tone appears mottled; weak cry.

Initial vital signs: Temp 34.1, heart rate 195, respiratory rate 80, unable to obtain blood pressure or pulse ox reading.

3.4. Web-Based Resources and Learning Unit

A variety of media were utilized to develop and maintain resident skill level. YouTube videos were used to demonstrate correct procedure skills and resuscitation techniques. Residents also had access to web-based materials which included information and rapid reference material discussed in the simulations (RSI medications, formulas, etc.). There were case scenarios and practice questions (with answers and discussion) that reviewed materials learned in simulations and reinforced recently acquired knowledge. The web-based module allowed residents to review at a self-pace and concentrate on areas where they need improvement.

4. Data Collection

To evaluate the feasibility of the instructional structure we utilized three sources of data, an objective simulation evaluation, a pre and post self-assessment and a pre and post-test. The data collection forms were as follows:

Simulation Data Collection Form (filled out by attending physician during simulation):

A simulation grading tool (see [Appendix A](#)) was used by the attending physician to grade resident and student performance during simulated patient scenarios. The forms were based on a Likert scale and were done as the resident participated in the simulation scenario. They were completed by a single grader and the grader was the same for all 4 simulated scenarios during their 4-week rotation. These forms were used to track resident progress throughout the training unit.

Pre and Post Self-Assessment Form

Again, utilizing a Likert scale, the residents completed a form prior to beginning the education unit and upon completion of the unit and the data were analyzed for differences between pre and post-assessment. The form was the same for both pre and post self-assessment.

5. Results

5.1. Data Collection

There were 8 residents that completed the resuscitation training module, 3 emergency medicine residents and 5 pediatric residents. The module was completed during their 4-week pediatric emergency medicine rotation. The sources of data were an objective simulation evaluation, a pre and post self-assessment and a pre and post-test. 100 % (8 residents) completed the self-assessments and pre and post-tests and course evaluations. The residents were also allowed to access the online material to augment their learning. The online component was self-directed and self-paced and residents could utilize it as much or as little as needed.

5.2. Simulation Scenario Results

Eight residents completed a total of 4 hands-on patient simulations. One of the initial challenges to completing the simulation scenarios was the concern for additional training time outside of their already scheduled activities. The simulations were conducted during the hours of their clinical shifts, so as not to add additional hours to their training schedules. These were done during times when the emergency department was not busy, so actual patient care was not compromised. The simulations usually consisted of 1 - 3 residents. Each resident was rotated through the role of team leader. When they were not acting as team leader they assisted in supporting roles during the simulation. The residents were only graded when they were acting as team leader. There was a total of

85 points possible each week. Individual scores were examined to evaluate the changes from week to week, especially the difference in scores from week 1 to Week 4 (**Table 1**).

Overall, the residents improved their scores from the beginning to the end of the training module. As a reflection of the overall simulation scores, the residents did show improvement in the performance of pediatric resuscitation. However, there were 2 individual residents that did not show much change in the scores over the 4 week time period, residents 5 and 7. Resident 7 consistently performed at a high level so there was not much room for improvement in their score. Resident 5 was the poorest performing resident of the group. It is unclear why this resident continued to perform at an average level and did not make significant improvements throughout the course. This resident did voice some discomfort about being involved in the simulations and feeling as if they were being “scrutinized” during the simulation. It is possible that the environment of simulated patients was extremely stressful for this resident, as they often commented that they did not feel comfortable being the team leader during the simulations. It also may be due to the fact that the resident did not choose to utilize the on-line materials that were available to them in order to improve during their rotation.

5.3. Pre and Post Self Assessments Results

The students were asked to complete self-assessments prior to starting the resuscitation training course and at the completion of the course. The students also had the opportunity to free text at the end of the self-assessment. On the pre self-assessment the students were asked to answer the question “The areas I need the most improvement include:” and on the post self-assessment they were asked the question “The areas I feel that I improved the most included:” and their free text answers were recorded if they chose to respond.

The following results are the resident’s answers to the self-assessments, their responses to each question given as a percentage as well as the actual number of respondents given in parenthesis. **Figure 1** is the pre self-assessment and **Figure 2** is post self-assessment results.

There were many questions contained in the pre and post self-assessment. In order, to summarize the results of the self-assessment the results are divided into categories that reflect the types of questions that were asked and chose to highlight the important findings in those categories.

5.3.1. Functioning as Team Leader and Team Communication

In the pre self-assessment, when asked “I feel comfortable functioning as a team leader” 50% disagreed and 37.5% strongly disagreed indicating they were not comfortable in the team leader role. However, 75% of the residents indicated that they were comfortable communicating with the medical team and 50% strongly agreed that they were comfortable delegating responsibilities to other team members. This indicated that the training should focus on building confidence as a team leader and ensuring the residents had good communication techniques in that leadership role. Curriculum modifications were made to ensure that a focus was placed on communication skills during the course. In the post self-assessment, when asked “I feel comfortable functioning as a team leader” there was an increase in the number of residents that agreed (50%) and strongly agreed (25%) in the post

Table 1. Resident simulation performance scores.

Resident	Week 1	Week 2	Week 3	Week 4	Difference in score from week 1 to week 4
Resident 1 (EM)	72	77	78	80	+8
Resident 2 (EM)	64	55	73	79	+15
Resident 3 (EM)	52	61	60	68	+16
Resident 4 (Peds)	48	55	49	57	+9
Resident 5 (Peds)	40	42	38	41	+1
Resident 6 (Peds)	65	74	66	78	+13
Resident 7 (Peds)	77	79	81	76	−1
Resident 8 (Peds)	66	70	65	72	+6
Average of all Residents performance	60.5	64.125	63.75	68.875	+8.375

	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
I know how to recognize a child that requires resuscitation	12.5% (1)	62.5% (5)	0%	25% (2)	0%
I am comfortable leading the team during a pediatric resuscitation	0%	50% (2)	12.5% (1)	50% (2)	37.5% (3)
I am comfortable communicating with the medical team	75% (6)	12.5% (1)	0%	12.5% (1)	0%
I am comfortable delegating responsibilities to team members	50% (4)	25% (2)	12.5% (1)	12.5% (1)	0%
I can recognize cardiopulmonary arrest	100% (8)	0%	0%	0%	0%
I can recognize impending cardiopulmonary arrest	50% (4)	12.5% (1)	0%	25% (2)	12.5% (1)
I can recognize an obstructed airway	37.5% (3)	62.5% (5)	0%	0%	0%
I can recognize respiratory distress	12.5% (1)	50% (4)	12.5% (1)	25% (2)	0%
I can recognize apnea	100% (8)	0%	0%	0%	0%
I can recognize a patient that will require intubation due to expected disease course	12.5% (1)	12.5% (1)	12.5% (1)	50% (4)	12.5% (1)
I can interpret lab data that indicate resuscitation is necessary	0%	50% (4)	12.5% (1)	37.5% (3)	0%
I am competent in assessing the pediatric airway	25% (2)	25% (2)	12.5% (1)	37.5% (3)	0%
I can anticipate a difficult airway	0%	50% (4)	0%	0%	50% (4)
I can correctly identify all the anatomic landmarks for intubation	12.5% (1)	25% (2)	12.5% (1)	50% (4)	0%
I am comfortable using oxygen delivery devices	75% (6)	25% (2)	0%	0%	0%
I am competent performing bag valve mask ventilation	62.5% (5)	12.5% (1)	0%	25% (2)	0%
I am competent in performing tracheal intubation including:					
Assembling and checking needed equipment	50% (4)	25% (2)	0%	12.5% (1)	12.5% (1)
Selecting correct laryngoscope blade	25% (2)	0%	12.5% (1)	50% (4)	12.5% (1)
Selecting correct endotracheal tube	50% (4)	25% (2)	12.5% (1)	12.5% (1)	0%
Direct laryngoscopy	37.5% (3)	50% (2)	12.5% (1)	12.5% (1)	12.5% (1)
Inserting endotracheal tube	50% (4)	12.5% (1)	12.5% (1)	25% (2)	0%
Verifying correct tube position by visualization and auscultation	50% (4)	25% (2)	0%	25% (2)	0%
Verifying correct tube position by adjuvant methods	25% (2)	50% (4)	0%	25% (2)	0%
I am competent in trouble-shooting a failed airway attempt	0%	12.5% (1)	25% (2)	50% (4)	12.5% (1)
I am competent in using an LMA	37.5% (3)	12.5% (1)	0%	50% (4)	0%
I am competent in using a bougie	37.5% (3)	0%	0%	62.5% (5)	0%
I am competent in using the glidescope	37.5% (3)	12.5% (1)	12.5% (1)	37.5% (3)	0%
I am competent in selecting resuscitation medications	37.5% (3)	50% (4)	0%	12.5% (1)	0%
Correct medication doses	12.5% (1)	37.5% (3)	12.5% (1)	12.5% (1)	12.5% (1)
Frequency for providing medications	25% (2)	62.5% (5)	12.5% (1)	0%	0%
Indications for medications	25% (2)	25% (2)	0%	50% (4)	0%
Route for medications	75% (6)	25% (2)	0%	0%	0%
I am competent post-intubation procedures:					
I can interpret the chest x-ray for correct ETT placement	100% (8)	0%	0%	0%	0%
I can secure the endotracheal tube	75% (6)	25% (2)	0%	0%	0%
I can select the correct initial ventilator settings	12.5% (1)	62.5% (5)	0%	25% (2)	0%
I am competent in performing CPR	100% (8)	0%	0%	0%	0%
I am comfortable instructing others to perform CPR	50% (4)	25% (2)	12.5% (1)	12.5% (1)	0%
I can recognize cardiac rhythms that require cardioversion	25% (2)	25% (2)	0%	50% (4)	0%
I am comfortable announcing time of death	0%	12.5% (1)	37.5% (3)	50% (4)	0%

Figure 1. Pre self-assessment results.

	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
I know how to recognize a child that requires resuscitation	62.5% (5)	37.5% (3)	0%	0%	0%
I am comfortable leading the team during a pediatric resuscitation	25% (2)	50% (4)	12.5% (1)	12.5% (1)	0%
I am comfortable communicating with the medical team	75% (6)	25% (2)	0%	0%	0%
I am comfortable delegating responsibilities to team members	50% (4)	25% (2)	12.5% (1)	12.5% (1)	0%
I can recognize cardiopulmonary arrest	100% (8)	0%	0%	0%	0%
I can recognize impending cardiopulmonary arrest	50% (4)	37.5% (3)	12.5% (1)	0%	0%
I can recognize an obstructed airway	62.5% (5)	37.5% (3)	0%	0%	0%
I can recognize respiratory distress	50% (4)	50% (4)	0%	0%	0%
I can recognize apnea	100% (8)	0%	0%	0%	0%
I can recognize a patient that will require intubation due to expected disease course	75% (6)	25% (2)	0%	0%	0%
I can interpret lab data that indicate resuscitation is necessary	37.5% (3)	50% (4)	12.5% (1)	0%	0%
I am competent in assessing the pediatric airway	75% (6)	25% (2)	0%	0%	0%
I can anticipate a difficult airway	25% (2)	50% (4)	25% (2)	0%	0%
I can correctly identify all the anatomic landmarks for intubation	50% (4)	25% (2)	25% (2)	0%	0%
I am comfortable using oxygen delivery devices	87.5% (7)	12.5% (1)	0%	0%	0%
I am competent performing bag valve mask ventilation	100% (8)	0%	0%	0%	0%
I am competent in performing tracheal intubation including:					
Assembling and checking needed equipment	50% (4)	50% (4)	0%	0%	0%
Selecting correct laryngoscope blade	62.5% (5)	25% (2)	0%	12.5% (1)	0%
Selecting correct endotracheal tube	50% (4)	37.5% (3)	12.5% (1)	0%	0%
Direct laryngoscopy	75% (6)	12.5% (1)	0%	12.5% (1)	0%
Inserting endotracheal tube	50% (4)	25% (2)	0%	25% (2)	0%
Verifying correct tube position by visualization and auscultation	50% (4)	50% (4)	0%	0%	0%
Verifying correct tube position by adjuvant methods	50% (4)	25% (2)	12.5% (1)	12.5% (1)	0%
I am competent in trouble-shooting a failed airway attempt	37.5% (3)	25% (2)	0%	25% (2)	12.5% (1)
I am competent in using an LMA	50% (4)	25% (2)	0%	25% (2)	0%
I am competent in using a bougie	62.5% (5)	12.5% (1)	12.5% (1)	12.5% (1)	0%
I am competent in using the glidescope	50% (4)	12.5% (1)	12.5% (1)	50% (2)	0%
I am competent in selecting resuscitation medications	37.5 (3)	37.5% (3)	12.5% (1)	12.5% (1)	0%
Correct medication doses	25% (2)	50% (4)	12.5% (1)	12.5% (1)	0%
Frequency for providing medications	50% (4)	25% (2)	12.5% (1)	12.5% (1)	0%
Indications for medications	50% (4)	50% (4)	0%	0%	0%
Route for medications	100%	0%	0%	0%	0%
I am competent post-intubation procedures:					
I can interpret the chest x-ray for correct ETT placement	100% (8)	0%	0%	0%	0%
I can secure the endotracheal tube	100% (8)	0%	0%	0%	0%
I can select the correct initial ventilator settings	37.5% (3)	37.5% (3)	0%	25% (2)	0%
I am competent in performing CPR	100% (8)	0%	0%	0%	0%
I am comfortable instructing others to perform CPR	100% (8)	0%	0%	0%	0%
I can recognize cardiac rhythms that require cardioversion	37.5% (3)	37.5% (3)	12.5% (1)	12.5% (1)	0%
I am comfortable announcing time of death	50% (4)	25% (2)	12.5% (1)	12.5% (1)	0%

Figure 2. Post self-assessment results.

self-assessment as compared to the pre self-assessment (0% strongly agreed and 50% agreed). This was an important finding since the education module did focus on practicing communication skills as the role of team leader in order to build confidence during resuscitations.

5.3.2. Recognizing Critically Ill Children Requiring Resuscitation

A majority of the residents (75%) indicated that they could recognize a child requiring resuscitation. 100% could recognize a child with apnea, however it appeared that they were not as confident recognizing a child with respiratory distress or anticipating which children would require intubation as part of their expected disease course as indicated by range of agreement with those statements. At the completion of the training, 100% of the residents indicated that they could recognize a child requiring resuscitation. 100% could recognize a child with apnea and cardiopulmonary arrest. There was an increase in positive responses in recognizing a child with respiratory distress or anticipating which children would require intubation as part of their expected disease course. The post self-assessment revealed that no resident indicated disagreement with the statement “I can recognize respiratory distress” (compared to 25% disagreement in pre self-assessment) and no resident indicated disagreement with the statement “I can recognize a patient that will require intubation due to expected disease course” (compared to 50% disagree and 12/5% strongly disagree in pre self-assessment). This data indicated a positive shift in resident’s confidence and perception of their own competence at the conclusion of the training module.

5.3.3. Pediatric Airway Skills

There was a wide range of responses to these questions involving how competent the residents felt at managing pediatric airways, such as assembling and checking equipment, selecting correct blades and sizes and inserting endotracheal tubes. Some residents felt extremely confident about these procedures as indicated by their strong agreement with the statements and some residents felt very uncomfortable with the skills as indicated by their strong disagreement by the statements. No resident indicated strong agreement with feeling competent with trouble-shooting a failed airway attempt and 50% indicated that they did not feel competent performing this task. This is extremely important since often a resident must attempt an intubation multiple times on a patient before successfully establishing a secure airway. There were also lower feelings of competency regarding the uses of airway adjuncts, such as an LMA, glidescope and bougie. This indicated that we needed to focus on having the resident learn to trouble-shoot failed airways and also to practice using airway adjuncts during their training. After completing the resuscitation training there was an overall trend in increased agreement in the statements of how competent the residents felt at managing pediatric airways, including assembling and checking equipment, selecting correct blades and sizes and inserting endotracheal tubes. There was a 50% increase in agreement statement of the residents feeling competent at assembling and checking intubation equipment, no resident indicated a disagreement in the post self-assessment. Of particular note, 37.5% of residents in the post self-assessment as compared to 0% of residents in the pre self-assessment indicated strong agreement with feeling competent with trouble-shooting a failed airway attempt. This was an excellent gain in the feelings of confidence in this area. More residents also indicated feelings of increased competency regarding the uses of airway adjuncts, such as an LMA, glidescope and bougie. This indicated to me that the on-line materials and hands-on simulation training were covering the topics that the residents felt a need to have improved training. This was reflected in the increase of agreement statements in the questions regarding managing pediatric airways.

5.3.4. Resuscitation Medications

Again there was a fairly wide range of agreement with statements of competency in using resuscitation medications. 50% of residents felt they were not competent in the knowledge of the correct indications for using the medications, but 75% were confident on choosing the correct route for the medications. This data showed that the focus of medication education needed to center around learning correct doses and indications for medications. In the post self-assessment there was only a small change in the area of use of resuscitation medications. Each agreement statement (agree, strongly agree) only increased a small percentage amount and some did not change at all. This result was surprising since both the on-line materials and simulations included a significant amount of medication education. This is obviously an area for improvement for this course. It may be an area that needs dedicated training time, instead of incorporating it into the other tasks that are focuses on during the training module.

5.3.5. Other Resuscitation Skills

100% of the residents stated they strongly agreed that they were competent performing CPR. I suspect this is because the residents receive specialized training and certification in CPR and are required to recertify every 2 years. This is a skill that they practice frequently during those certification trainings. Only half of the residents strongly agreed or agreed that they were competent recognizing cardiac rhythms that required cardioversion the other half stated they were not competent in this area. This information allowed incorporation of rhythm recognition and practice with the defibrillator into the simulated scenarios so that they could get experience in this area. Also, only 12.5% (1 resident) indicated that they felt competent in announcing the time of death after an unsuccessful resuscitation. This data allowed changes to be made to one of the scenarios to include the fact that the patient did not live so that the residents had the opportunity to discuss how to decide to call time of death. In the post self-assessment, there was increased agreement in the statements of competency regarding rhythm recognition. Only one of the residents disagreed that they were competent recognizing cardiac rhythms that required cardioversion as compared to 3 residents in the pre self-assessment. Also, 50% (4 residents) strongly agreed and 25% (2 residents) agreed that they felt competent in announcing the time of death after an unsuccessful resuscitation. This was a large increase in agreement as compared to the pre self-assessment data. This data was very important since modifications were made to some of the learning activities of the scenarios to include a patient did not live so that residents had the opportunity to discuss how to decide to call time of death. This turned out to be very beneficial for the residents.

In the pre self-assessment the residents were also asked to free text an answer to “The areas I need the most improvement include”, their responses are displayed in [Table 2](#).

The free text responses reflected their choices in the self-assessment closely. It was clear that the residents were not as comfortable with equipment, intubation and medications. Of note, none of the residents mentioned that they felt they needed to improve in the role of team leader, which they clearly indicated was an area of difficulty for them on the self-assessment.

The data obtained from the pre self-assessment was invaluable in guiding curriculum modifications to better fit the needs of the residents and where they perceived their weakness to be. Educational materials were tailored in both the on-line materials and hands-on activities to focus their attention to these weaker areas.

On the post self-assessment the residents were also asked to free text an answer to “The areas I feel that I improved the most included” their responses are displayed in [Table 3](#).

The free text responses were helpful in getting feedback about the training. Two of the residents commented on acting in the role of team leader and communication. This is clearly an area that they continue to struggle with confidence in. The residents commented on improved airway skills and rhythms. One of the residents commented on the continued concern of choosing appropriate medications. These comments allowed determination of where areas of training were lacking and need improvement.

5.4. Pre and Post-Test Results

The residents completed a pre-test prior to starting the resuscitation training course and a post test at the completion of the course. There were a total of 20 points available for the test (see [Table 4](#)).

The overall average of the residents improved by 1.875 points from the pre-test to the post-test. Most residents, except for 2, scored better on their post-test than their pre-test. Although this was a small change, it was in a positive direction and it indicated that the training has potential to increase in their clinical knowledge regarding

Table 2. Resident pre self-assessment responses.

Resident Responses to “The areas I need the most improvement include:”
“I struggle with picking the right equipment for intubation. It is difficult for me to choose the right kind of blade and size of things for pediatric patients”
“I never know what kind of medications I should use for RSI drugs. It seems like there are so many different combinations, it’s hard to know which ones are the right ones to use”
“I don’t really know what to do in a pediatric resuscitation. The whole thing is overwhelming to me. I could use help with all of it”
“Infant resuscitations are very difficult. They are so small and the airways are really different”
“Picking the right equipment sizes. Knowing where to place the ETT (endotracheal tube)”

Table 3. Resident post self-assessment responses.

Resident Responses to “The areas I feel that I improved the most included:”
“I am much more comfortable with the overall process of pediatric resuscitations, although it is still hard for me to pick the right drugs”
“I’m better at selecting the right equipment and putting it together”
“I am better as a team leader, although I still find that position intimidating. I am more confident now in the choices I have to make and making them quicker in stressful situations”
“I hope I will be better at actual intubations”
“I am better at expressing myself in a chaotic environment”
“I like that we got to practice and learn pediatric resuscitations but I still feel like I have a long way to go before I am good at it. I could still use more practice on rhythms, but I am better at it than I was before”
I loved using the online website to review what we learned during the simulations. Even though I had to spend my own free time doing it, I think it was worth it!

Table 4. Resident pre and post-test results.

Resident	Pre-test Score	Post-test Score	Change in Score
Resident 1 (EM)	16	17	+1
Resident 2 (EM)	14	18	+4
Resident 3 (EM)	16	13	−3
Resident 4 (Peds)	12	16	+4
Resident 5 (Peds)	8	11	+3
Resident 6 (Peds)	16	15	−1
Resident 7 (Peds)	13	15	+2
Resident 8 (Peds)	10	15	+5
Average of all Residents performance	13.125	15	+1.875

pediatric resuscitations.

6. Implications for Practice

Blended learning is a relatively new technology based approach in medical education. The overall goal of this study was to evaluate a teaching module that used a blended learning environment to enable pediatric and emergency medicine residents and medical students to become successful, competent, confident, and skilled at pediatric resuscitations and retain these skills and knowledge throughout their training.

Overall, the blended learning approach showed a positive trend in successfully educating residents about pediatric resuscitations and increasing their self-confidence for performing resuscitations. The results reflected both a trend in increased knowledge in pediatric resuscitation as well as a self-perceived increase in confidence in many of the skill areas of pediatric resuscitation. One of the curriculum’s goals was to support face-to-face learning with self-directed online activities to help meet the individual learning needs of the residents. This blended learning project was conducted during the resident’s 4 week clinical rotation in the pediatric emergency department. It was the key to remain flexible with the residents’ schedule as to not add more hours to their training schedules and some of the components had to be modified to work within a 4-week period.

7. Conclusion

This was a small study designed to evaluate the feasibility of using a blended learning instruction technique in the pediatric emergency department in an academic institution. We also gathered preliminary data to evaluate trends toward learning and skill acquisition during the time of this study.

First, constructing a blended learning environment to facilitate medical education for residents and students can be a successful way to increase both knowledge and confidence. Taking care of a critically ill child can be a

relatively rare event during residency, even for experienced 3rd year residents, therefore it is imperative that we provide an environment for residents to practice pediatric resuscitation skills and to continually develop their knowledge to increase their competence and confidence. As a reflection of their pre and post test scores, it was clear that there was a trend in improved knowledge base at the completion of the 4-week course. Also, there was a consistently more positive response of most of the questions in the post self-assessment, reflecting an overall increase in their level of confidence performing the components of a pediatric resuscitation. Overall, the residents expressed increased self-confidence. The residents seemed to make critical decisions more rapidly and engage themselves in the role of a leader. They seemed eager to learn and improve in the areas that they identified as weak for themselves. They appeared to be utilizing the online materials to “practice” before they participated in simulations so that they could get the right answers. Creating a blended learning environment appears to be an effective way to deliver pediatric resuscitation education. It was important to allow flexibility in the curriculum to adjust to the expressed needs of the residents during their clinical rotation. Modifying the curriculum was particularly beneficial during the inquiry in regards to education about addressing difficult pediatric airways and how to handle a death of a pediatric patient. The simulation scenarios toward the end of the rotation were modified to address these needs as they became apparent during their rotation. This allowed the residents to increase their skills and confidence in the areas as reflected by their post self-assessment results.

Second, patient simulation may not be the best way to reach every student. The face-to-face component of this inquiry consisted of patient simulation. Most of the residents seemed to function well as the team leader and did not appear to be intimidated by the simulation experience. However, as noted in the results, Resident #5 consistently performed at a lower level than her peers based on subjective evaluation. As a resident, her personality tends to be quieter and shy. She prefers to listen passively and rarely verbally contributes to a medical discussion unless prompted by the attending to do so. She was clearly uncomfortable in the role as team leader. The educator may need to consider integrating different types of face-to-face learning activities for this module. While simulation seems to be effective for a majority of the residents, it is not effective for every resident and there needs to be other types of face-to-face learning activities to accommodate for these learning styles. The same resident did say that she enjoyed the online learning materials and thought they were helpful for her integrating the things which she was learning during her rotation. She did benefit from the use of the blended learning environment so this was a positive impact.

Third, there was a large volume of information to be covered in a 4-week time period. Sometimes the residents appeared frustrated and tired. The residents seemed to struggle with medication indications and dosages throughout the module. There was not much of a change in resident agreement in the pre and post self-assessments in the area of medication usage. A comprehensive module such as this may have too much information to learn in such a short period of time, so consideration should be giving into breaking materials down into components. This area is particularly challenging for medical educators since they need to know such a large amount of material to be competent.

8. Future Directions

A blended learning environment can be used to teach medical skills and knowledge successfully. In this study, a blended learning module was created and conducted for pediatric resuscitation education utilizing hands-on simulation and online learning materials to help facilitate learning and confidence for pediatric and emergency medicine residents during their 4-week clinical rotation. A few issues to be addressed in future educational endeavors. First, incorporation of other face-to-face components of the module such as small group discussion centered on patient based learning. One modification to this particular teaching curriculum could include decreasing the number of patient simulations to 2 per rotation and adding case based learning exercises to accommodate different types of learners. Second, dividing the educational content in the training module into separate components to focus on specific skills and core knowledge during a 4-week rotation and rotate these topics during the year. Breaking the current curriculum into airway management, resuscitation medications, management of pediatric arrhythmias and other resuscitation skills and team building and communication could be a future development. And lastly, utilization of other online tools for delivery of educational content, such as wiki spaces, Google hangouts, Facebook, etc. to allow a more interactive on line experience.

All of these things are important to consider since implementing a blended learning approach to teaching pediatric resuscitation within the clinical setting can allow the teacher to utilize a variety of teaching modalities to

accommodate different types of learners. It also allows residents and students to increase self-confidence and bridge the gap between knowledge and practice in pediatric resuscitations. A blended learning approach can be used successfully in the pediatric emergency department. Blended learning contexts can be used to help address some of the issues facing medical education at this time. Such as the need to standardize educational content, working with limited faculty resources and funding, accommodating the residents work hour restrictions while providing the ever increasing amount of core content materials and providing learning autonomy and improved efficiency. Sometimes these demands can feel overwhelming to the clinical educator, however, blended learning environments can be an excellent way to address many of these challenges faced in medical education while improving the overall educational experience for our residents.

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Appendix A

Simulation Grading Tool

Performance of pediatric resuscitation

Task	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Learner identifies need for and initiates resuscitation	5	4	3	2	1
Learner consistently verbalizes thoughts to medical team	5	4	3	2	1
Learner identifies need for intubation	5	4	3	2	1
Learner selects appropriate equipment for intubation	5	4	3	2	1
Learner selects correct blade and ETT size for intubation	5	4	3	2	1
Learner initiates CPR when necessary	5	4	3	2	1
Learner modifies equipment selection based on specific disease or patient characteristics when appropriate	5	4	3	2	1
Learner identifies cardiac arrhythmias correctly	5	4	3	2	1
Learner uses defibrillator correctly	5	4	3	2	1
Learner communicates with team effectively	5	4	3	2	1

Total score _____

Selection of appropriate resuscitation medication

Task	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Learner initiates IV fluids	5	4	3	2	1
Learner selects appropriate sedative medication for intubation	5	4	3	2	1
Learner selects appropriate paralytic medication for intubation	5	4	3	2	1
Learner determines if adjuvant medications are necessary	5	4	3	2	1
Learner gives medication in correct order	5	4	3	2	1
Learner recognizes if any medications are contraindicated for patient	5	4	3	2	1
Learner gives appropriate medications for diagnosed disease process (i.e. prostaglandin, steroids, glucose)	5	4	3	2	1