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Game-Based Refresher Training for Registered Nurse Providers of Neonatal Resuscitation

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Abstract

Based on evidence suggesting resuscitation provider knowledge and skill decay can occur as soon as four weeks post-training, the American Heart Association (AHA) recommends more frequent resuscitation refresher training. While current resuscitation training and education practices center on simulation training, its cost in terms of supplies, equipment, and personnel may be creating barriers to increasing the frequency of refresher training. This quality improvement project implemented a game-based, refresher training for registered nurse providers of neonatal resuscitation with a focus on improving the time to initiation of positive pressure ventilation (PPV) per Neonatal Resuscitation Program (NRP) guidelines. Using commonly available free or low-cost software programs, three self-directed, online games were developed which aimed to stabilize or improve neonatal resuscitation knowledge and skill. Participant knowledge and skill were assessed pre- and post-game play using a standardized simulation scenario. Participant levels of motivation and engagement with the learning materials were assessed with the Instructional Materials Motivation Scale (IMMS). Statistically significant improvements in knowledge and skill and time to PPV initiation were noted at six weeks post-game play, with an overall mean improvement of almost thirteen seconds in the start time of PPV. Participants found the learning materials to be motivating, engaging, and relevant to their current practice. Project results suggest that a low-cost, game-based, refresher training can stabilize or improve neonatal resuscitation provider knowledge and skill, leading to better outcomes for newborns requiring resuscitation after birth.

Keywords: neonatal resuscitation, positive pressure ventilation, game, game-based, refresher training, motivation

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Almost four million babies are born in the United States each year (Mathews & Hamilton, 2019). The transition from intrauterine to extrauterine life involves a rapid and complex series of physiological events that enable the newborn to shift from placental to pulmonary respiration (Wycoff et al., 2020). While most make this transition successfully within the first minute of life, almost 10% of newborns will require some intervention after birth to initiate respiration, and 5% of newborns will need positive pressure ventilation (PPV) to provide their essential first breaths (Weiner & Zaichkin, 2021; Wycoff et al., 2020). For almost 200,000 U.S. babies born each year, morbidity and mortality related to respiratory failure and birth asphyxia may be reduced or prevented through skilled and timely resuscitation support (Linde et al., 2018; Wykoff et al., 2020).

In 1987, the American Academy of Pediatrics (AAP), in partnership with the American Heart Association (AHA), launched the Neonatal Resuscitation Program (NRP), an evidence-based resuscitation training program aimed at improving the outcomes of newborns requiring resuscitation (Weiner & Zaichkin, 2021). In collaboration with the International Liaison Committee on Resuscitation (ILCOR), the AAP and AHA conduct an extensive literature and evidence review every five years and then revise the NRP curriculum to reflect the best resuscitation evidence available (Kattwinkel, 2008). Over four million healthcare providers in 130 countries have been NRP trained or retrained, with approximately 200,000 learners completing the NRP Provider Course each year (American Academy of Pediatrics, 2021). Course participants complete a self-directed, web-based curriculum and knowledge test, followed by a four-hour in-person, instructor-led course which includes a series of skills stations, simulations, and a formal debriefing (Weiner & Zaichkin, 2021). Upon successful course completion, participants are considered capable providers of neonatal resuscitation. Neonatal resuscitation providers are required to maintain their "current" status by completing the same course every two years. (Weiner & Zaichkin, 2021)

Recent evidence in resuscitation science literature suggests that resuscitation provider knowledge and skill decay may begin as soon as one month after the completion of a resuscitation course such as NRP (Aziz et al., 2020; Bhanji et al., 2015; Perlman et al., 2015). Based on this evidence, AHA guidelines recommend increasing the frequency of refresher training for hospital resuscitation providers to mitigate knowledge and skill decay (Aziz et al., 2020; Bhanji et al., 2015; Perlman et al., 2015). NRP, like other AHA resuscitation programs, is a simulation-based training program. While simulation can be an effective instructional modality, simulation training is costly in terms of equipment, supplies, and personnel. This fiscal burden can create a substantial barrier to adopting the AHA's recommendation of more frequent training (Cheng et al., 2018; Gerard et al., 2018; Ghoman et al., 2020). To better understand the problems associated with resuscitation knowledge and skill stability and to identify challenges or opportunities regarding resuscitation refresher training, a review of the evidence was completed.

Literature Review

A literature search of the PubMed, CINAHL, Cochrane, Google Scholar, and Web of Science databases was performed for the years 2015-2021. Keywords included "neonate," "newborn," "resuscitation," "neonatal resuscitation," "positive pressure ventilation," and "outcomes." Studies tended to be observational or descriptive in nature, often in populations from low-resource countries that may have inadequate access to training or equipment for neonatal resuscitation. Lee et al. (2011) performed a systematic review and meta-analysis of 24 studies completed in low-resource countries to estimate the effect of neonatal resuscitation training on neonatal mortality and concluded that structured neonatal resuscitation training and timely intrapartum intervention reduced term intrapartum death by 30% (RR=0.07, 95% [CI 0.59-0.84]). Bang et al. (2016) and Arlington et al. (2017) both examined the effectiveness of structured neonatal resuscitation training, including an assessment of the timing of refresher training. During a pre-evaluation of participants at a six-month refresher training Bang et al. (2016) found no deterioration in knowledge; however, a significant deterioration in skills occurred ($p < 0.0001$). Arlington et al. (2017) found deterioration of skills at four to six weeks post-training and another significant decrease at four to six months post-training ($p < 0.001$).

Delays in the initiation of positive pressure ventilation in the apneic newborn may increase the risk of hypoxic injury (Ersdal et al., 2012), informing NRP practice guidelines and the training of NRP providers to initiate PPV by one minute of life for the apneic or gasping newborn (Wycoff et al., 2020). In the literature, two descriptive observational studies by Niles et al. (2017) and Shikuku et al. (2018) described post-training deterioration in knowledge and skills in the resuscitation of newborns. Niles et al. (2017) found only 45% of 1135 newborns born at a large academic center had PPV initiated per NRP guidelines and only 54.6% of 66 newborns requiring resuscitation had PPV initiated by one minute of life in the Shikuku et al. study (2018). This body of evidence reveals skill decay for providers of neonatal resuscitation exists and likely impacts neonatal outcomes.

Researchers examining the problem of skill decay in neonatal resuscitation providers suggest the development and implementation of frequent refresher or booster training to address the problem (Arlington et al., 2017; Bang et al., 2016; Bhanji et al., 2015; Cheng et al, 2018; Lee et al., 2011; Niles et al., 2017; Shikuku et al., 2018). Only one study, Mduma et al. (2015), attempted to suggest a frequency of refresher training; they found a monthly cadence of brief simulation-based refresher training decreased the need for PPV by 2 % ($p = 0.005$) and decreased mortality at 24 hours of life by 4% ($p = 0.04$). Suggested learning modalities for refresher training included simulation-based training (Bender et al., 2014; Vail et al., 2018), in-person or virtual instructor-led training (O'Currain et al., 2019), self-directed training (Mackinnon et al., 2016), and cognitive aids, including the use of technology in the form of apps or interactive games (Ghoman et al., 2020). In an AHA scientific statement on resuscitation education science, Cheng et al.'s (2018) assessment of the evidence and expert opinion also includes a recommendation for the deliberate use of an instructional design that will provide context, mastery through deliberate practice, feedback, and innovation when planning a refresher or booster training. While none of the literature revealed strong evidence for any single learning strategy or modality for neonatal refresher training, instructional design using innovative gamification or game-based learning may be one solution.

"Gamification" and "game-based learning" are terms used to describe the use of game strategies or game elements to enhance participant engagement and motivation during an education or training event (Deterding et al., 2011). As an education or training modality, game-based learning has been used across multiple disciplines, including health care (Brull & Finlayson, 2016; Costa et al., 2018; Gerard et al., 2018; Mawhirter & Garofalo, 2016; Thomas et al., 2020). In a review of twelve games (four board games, five video games, and three virtual reality games) used for neonatal resuscitation education and training, Ghoman et al. (2020) found some positive knowledge gains and examples of improved communication and decision-making, noting that the games were less expensive in terms of initial investment and had the ability to provide training on a larger scale. While game-based learning has been intermittently applied in both pre-licensure and professional nursing (Brull & Finlayson, 2016; Song et al., 2022; Xu et al., 2021), the potential for success and lower cost may make game-based learning design even more appealing when considering increasing the frequency of resuscitation provider retraining.

Theoretical Framework

John M. Keller's Attention, Relevance, Confidence, and Satisfaction (ARCS) model for motivational design has been chosen as the theoretical framework to inform the instructional and motivational design of the proposed intervention (Keller, 2010). The ARCS model is based on an assumption that motivation to learn is enhanced when (1) learner attention is activated, (2) the knowledge gained is relevant to the learner's goals, (3) the learner believes they will successfully complete the learning task, and (4) the learner anticipates and experiences a satisfying or positive outcome. Keller's model has been used in multiple studies of prelicensure nursing student education (Foli et al., 2016; Gormley et al., 2012; Stockdale et al., 2019), as well as in some recent examinations of motivational design in professional nurse education (Bonn et al., 2022; Woolwine et al., 2019). Woolwine et al. (2019) applied the ARCS model of motivational design in their development of a gamified nurse onboarding event, finding significant positive correlations to the improvement of learner motivation ($p < 0.05$). In a majority of the aforementioned literature, gamification or game-based learning design strategies were found to positively influence learner motivation and engagement.

Project Purpose

Despite evidence from the literature that aligns with AHA evidence-based guidelines (Aziz et al., 2020; Bhanji et al., 2015; Perlman et al., 2015), the implementation of frequent resuscitation training for neonatal resuscitation providers has not been consistent across practice settings, including the investigator's current practice setting. The purpose of the DNP project was to improve neonatal Registered Nurse (RN) NRP knowledge and skills specific to the first minute of life, with a focus on the timely initiation of PPV. To that end, this project implemented a self-directed, game-based refresher training for RN providers of neonatal resuscitation in a Level II nursery of a Northern California pediatric academic medical center. Participant motivation and satisfaction relative to the use of game-based elements in the instructional design of the refresher training were also evaluated. Two specific aims of this project were to reduce the average time of initiation of PPV to sixty seconds of life per NRP guidelines and to explore the feasibility of using game-based refresher training as an educational practice.

Methodology

Project Design

This quality improvement project used a descriptive, quasi-experimental design to assess the effect of self-directed, game-based refresher training on the neonatal resuscitation knowledge and skills of the neonatal RNs at Lucile Packard Children's Hospital at Stanford's Special Care Nursery (SCN) at Sequoia Hospital.

Participants

Project participants were neonatal RNs who identified the Sequoia SCN nursery as their home unit and are current neonatal resuscitation providers. All neonatal RNs who work in the SCN nursery are required to maintain their standing as neonatal resuscitation providers as a condition of their employment. Nurses who temporarily floated to the unit and travel or agency nurses were excluded as they were unlikely to be available for the entire project period.

Setting

The project took place at the Lucile Packard Children's Hospital at Stanford's (LPCHS) Special Care Nursery located inside the Birth Center at Sequoia Hospital in Redwood City, California. The nursery is a satellite site that serves babies born on-site who may require intensive care, as well as babies born at LPCHS who require a longer convalescence and may be transferred to this site for further care. The Special Care Nursery (SCN) team consists of RNs, physician hospitalists, Sequoia Hospital respiratory therapists, and secretarial support staff. The birth center averages 80 births per month.

The SCN's core shift staffing is three neonatal RNs and one physician hospitalist. One SCN RN is assigned to attend any birth occurring during each twelve-hour shift. The SCN RN performs all pre-birth assessments for risk, consulting as needed with the hospitalist and obstetrical staff. The SCN RN in most instances will be the only SCN team member in attendance at the birth due to the generally low-risk nature of the obstetrical population in the birth center. The SCN RN initiates and leads resuscitation efforts in the event of an unexpected birth of an apneic newborn until the hospitalist and a respiratory therapist arrive to assist.

Data Collection

All data were collected by the investigator. To maintain confidentiality and provide for the pairing of data, participants created their own seven-digit participant identification number to be used on surveys and scoring rubrics. The number consisted of the first three digits of the participant's cellular phone number and the first four digits of their address street number. If the participant's address street number is less than four digits, participants added the number of zeroes in front of the street number needed to equal four digits. The investigator did not use a key to link the participant to their identification number. Participants completed the Instructional Materials Motivation Scale (IMMS) on SurveyMonkey™, an electronic survey tool on a password protected LPCHS server. The investigator administered all pre- and post-game simulation scenarios and completed all rubric scoring. All demographic data, rubric score sheet data, and electronic survey data were transferred to a spreadsheet on a password protected LPCHS server, and all paper demographic surveys and scoring rubrics were shredded.

Instructional Materials Motivation Scale

The IMMS was used to assess participants' level of motivation in response to the refresher training intervention (Appendix C). The IMMS was developed by John Keller in 1987 as a complementary measurement tool to his ARCS model of motivational design for learning (Keller, 2010). There are 36 statements scored using a Likert scale, with the number "1" representing "Not True" and the number "5" representing "Very True." Total scores may range from a minimum of 36 to a maximum of 180. Participants are instructed to read each statement as it relates to the learning event and materials and indicate how true the statement is. The survey contains four subscales that correspond to the four components of the ARCS model: attention, relevance, confidence, and satisfaction, and each subscale may be used and scored alone or together for a total scale score (Keller, 2010). Maximum scores for each subscale are 60 for attention, 45 for relevance, 45 for confidence, and 30 for satisfaction. Keller does not designate a high or low score but considers the scale to be a situation-specific measure that is best used in comparison with subsequent scores or by the scores of a comparison or control group (Keller, 2010). In an examination of the survey's reliability and validity, ninety undergraduate students were randomly assigned to one of two lessons. Each lesson had the same learning objectives and content, but the experimental group's lesson was enhanced with motivational design strategies. Both groups completed the IMMS post-instruction. Scores for the motivationally designed lesson were significantly higher than the standard lesson. The results of the IMMS were analyzed using Cronbach's alpha and the internal consistency estimates were deemed satisfactory for the total scale and for each subscale (Keller, 2010).

The IMMS has been utilized and validated as a reliable tool to assess learner motivation and engagement in a number of studies (Cook et al., 2009; Hauze & Marshall, 2020; Huang et al., 2006; Jang et al., 2005; Loorbach et al., 2015). Cook et al. (2009) examined the IMMS's validity for healthcare provider education during an examination of the motivational differences between two web-based instructional interventions on 74 internal medicine residents. Adequate reliability was noted, with internal consistency, based on Cronbach's alpha, at ≥ 0.75 for all IMMS subscales and 0.93 to 0.95 for all 36 items together (Cook et al., 2009). Cook et al. (2009) also reported that IMMS scores were not sensitive to the variation of the two instructional designs used to deliver identical content. The authors noted that their internal consistency data results were similar to those of Keller (2010) and a study using a Korean translation of the IMMS (Jang, et al., 2005). These findings indicate that the IMMS is a valid and appropriate tool for assessing participant motivation in response to a self-directed refresher training intervention.

Simulation Performance Rubric

A simulation scenario to evaluate neonatal resuscitation knowledge and skill was administered by the investigator both pre-intervention and post-intervention (Appendix B). A standardized scenario adopted from the *Textbook of Resuscitation, 8th Edition* (2021) was used to assess knowledge and skill performance before and after the intervention. Participants were evaluated via direct observation as they progressed through the NRP algorithm, using a Laerdal SimNewB® simulator. The scoring rubric evaluated items in six different categories: perinatal risk assessment, resuscitation equipment checks, rapid evaluation of the newborn at birth, initial steps at the radiant warmer, assessment of respiratory effort, and the initiation and performance of PPV. Possible scores for each category varied (2-6 points) with a total possible score of 22 points. The time to the initiation of PPV was also recorded on the scoring rubric. The skill assessment took approximately five to seven minutes and was completed during the participant's work shift.

Participant Demographics

Participant demographics were collected when participants completed the pre-intervention simulation scenario.

Procedures

The project was publicized by the investigator through informational email, change of shift huddles, and unit flyers. During this time, the investigator provided a link to "The First Minute" participant portal. "The First Minute" participant portal was a website created to inform participants of the purpose and aims of the quality improvement project and to provide easy, one-click access to the intervention's games and post-intervention electronic surveys. Two webinars were held to show participants how to navigate the participant portal and a sample game. Prior to game access, participants completed an in-person, standardized neonatal resuscitation scenario of a term infant requiring the initiation of PPV to determine baseline resuscitation knowledge and skill performance.

During a twelve-week period, three online games were available to participants via the participant portal. Flyers with QR code access were posted in the unit, and participants were also emailed one-click hyperlink access to the portal, games, and IMMS every five to seven days during the twelve-week period. Technical support was available on-demand from the investigator and was advertised as being available in-person, or by phone call, email, or text. Participation was self-directed, meaning participants could choose which games to play, how many times to play, and when to play. Participants were asked to complete the IMMS to evaluate each of the three games' instructional design as it related to learning motivation and satisfaction. The same standardized neonatal resuscitation scenario used in the pre-intervention period was completed by participants six weeks after the closure of the participant portal.

Educational Intervention

The intervention was a set of self-directed, online refresher educational games that targeted neonatal resuscitation knowledge and skills. Rather than retraining to the entire NRP curriculum, the education focus was on pre-birth preparation, thermoprotection, and the first minute of the NRP algorithm, culminating in the decision to initiate PPV. The games were originally designed for the project using an augmented reality open-source platform for game construction. However, when the owners of the platform chose to discontinue platform support, a decision was made to reconstruct the games using the Google Docs Editors™ suite of programs, including the use of Google Sites™, Google Slides™, Google Forms™, and Google Sheets™. The game design included the purposeful application of multiple game elements known to bolster participant engagement and motivation, such as storytelling and theme, points, puzzles, time pressure, autonomous choice, immediate feedback, and a leaderboard that included a "top ten" list of PPV initiation time in seconds (Deterding et al., 2011; Rahman et al, 2018; Rutledge et al., 2018). Additionally, a systems approach ensured essential elements were infused throughout each game to appeal to the varied engagement and motivation levels of the anticipated participants (Rutledge et al., 2018). Each game used a different newborn birth scenario: the term newborn, the preterm newborn, and the term newborn with meconium-stained fluids. Each game required the participant to watch short videos, solve puzzles, and complete knowledge checks to unlock the next task, culminating in a "choose your own adventure" birth scenario that progresses to the initiation of PPV. Each participant initiated a timer at the start of the birth scenario and recorded their time to initiation of PPV on the leaderboard. The intervention used a self-directed learning approach consistent with current learning strategies employed during the COVD-19 global pandemic. Self-directed learning presents unique challenges to learner motivation, including the loss of the ability to monitor for changes in learner motivation that can be mitigated during instructor-facilitated learning (Keller, 2010). Evidence review noted encouraging results when educators implemented John Keller's ARCS model of motivational design during instructional design, including self-directed instructional design (Abbott, 2019; Gormley et al, 2012; Lajane et al., 2021; Refat et al, 2020; Woolwine et al., 2019), so the ARCS model of motivational design was applied in parallel during the instructional design and build of the games.

Following Keller's motivational design process, a systematic analysis was completed prior to instructional game design and build (Keller, 2010). During the analysis, anticipated motivational challenges or advantages were identified. Primary anticipated motivational challenges for the project that were considered included lack of confidence with, and fear of, technology, and a fear of failure, all of which may diminish motivation to the point of avoiding gameplay (Keller, 2010). In addition, the participant sample consisted of highly experienced and long-tenured nurses who may not self-identify a need for additional instruction and therefore have little to no motivation to engage in gameplay.

Game build and design elements were selected to target each of the four motivational components of the ARCS model. Strategies used to capture and maintain participant attention included the use of a story format, varied tasks to complete in order to advance through the game, and aesthetic enhancements designed to attract attention, including attractive colors, graphics, animation, and audio clips. Design elements used to clearly identify the relevance of the instruction included scenarios and case studies familiar to the participants' work environment and experience, a music video montage of the new content from the NRP 8th edition textbook, an animated video review of pre-birth planning, and a culminating choose-your-own-adventure delivery scenario ending in a debrief describing the applicable importance of PPV to patient outcomes. Participant confidence was targeted through clear objectives and task requirements. During gameplay participants also had opportunities to feel confident and successful by allowing multiple attempts to complete puzzles and tasks, receiving feedback, and having opportunities for remediation during the choose-your-own-adventure birth scenarios. Participant satisfaction was targeted with the use of standardized game content and measurements of success, including the use of game leaderboards to record participant scores after gameplay to create a sense of competition (scores were tallied for the top ten participant scores). The self-directed approach satisfies the participant's need to access the games at any time during the project period and allows for progress through the games at the participant's own pace.

Data Analysis

Demographic data were analyzed using descriptive statistics. Paired sample *t*-tests were used to examine pre- and post-game play simulation scenario rubric scores and pre- and post-game playtime to initiation of PPV. Post-game play IMMS total and subscale scores were examined using a repeated-measures ANOVA analysis of mean scores and standard deviation. A Spearman's correlation analysis was also completed to examine a possible relationship between the number of game plays and either rubric scores or time to PPV initiation. Statistical analysis was done using IntellecticusStatistics™ online software.

Ethical Considerations

This project was reviewed by the IRB at Stanford University and San Jose State University and was approved to proceed as a quality improvement project as the project did not meet the definition of human subjects research. There was no greater than minimal risk as participants were participating in an assessment of their knowledge and skills at the level expected in their role as neonatal resuscitation providers. The potential benefits to participants included the opportunity to enrich, advance, and stabilize their knowledge and skill in neonatal resuscitation essential to their role in the SCN. There were no costs to the participants or payments for participation in the project.

Results

Participant Demographics

The project participants (19) were all registered nurses who identify as neonatal resuscitation providers. Participants were mostly female (94.74%), between the ages of 51and 65 years old (73.69%). The highest degree attained by participants was the BSN (68.42%), followed by the ADN (21.05%). The majority of participants (73.69%) had worked as a neonatal nurse for sixteen or more years, and almost half (47.37%) had 31 or more years of practice in neonatal nursing. When assigned to the delivery nurse role, participants reported they attended an average of 11 births per month. Almost two-thirds of the participants (63.16%) reported they initiated PPV at 1-2 births per month (Appendix A).

Simulation Rubric Score and Time to Initiation of PPV

A standardized simulation scenario and scoring rubric were used to assess participant knowledge and clinical application of the NRP algorithm two weeks before and six weeks after the twelve-week period of game access. The scoring rubric measured the participant's completion of expected behavioral skills and decisions during the standardized scenario. A two-tailed paired samples *t*-test was conducted to examine whether the mean difference of the simulation scoring rubric pre-score and post-score was statistically significant. Assumptions for normality and homogeneity of variance were met and the results were significant based on an alpha value of .05, t (18) = -3.02, p = .007, with the mean of the pre-score significantly lower than the mean of the post-score.

A second two-tailed paired samples *t*-test was conducted to examine whether the mean difference of the time to initiation of PPV before and after the twelve-week period of game access was statistically significant. Assumptions for normality and homogeneity were met and the result of the two-tailed paired samples *t*-test was significant based on an alpha value of .05, t (18) = 2.21, p = .040, indicating the mean time of initiation of PPV before game access was significantly higher than the mean time of initiation of PPV six weeks after the period of game access was over.

Game Play and the Instructional Materials Motivation Scale (IMMS)

Individual IMMS scores were computed for the total overall score and for each of the four subscales; these scores were then aggregated to determine a mean overall score and a set of subscale scores for each individual game. Finally, a mean overall score and set of subscale scores for all games in total were computed. The mean overall score for all games played was 4.05 or "mostly true" that the games engaged and motivated the participants. Overall subscale mean score analysis showed participants rated the relevance of the games to be between "mostly true" and "definitely true" (4.43), confidence to complete the game tasks at "mostly true" (4.2), attention gain and maintenance attributed to game design at between "moderately true" and "mostly true" (3.87) and satisfaction towards game materials to be between "moderately true" and "mostly true" (3.67). Game 3, the meconium-stained delivery case scenario, had the highest mean scores as an individual game for its overall engagement and motivation (4.2) and for attention (4), relevance (4.5), confidence (4,4), and satisfaction (4).

Not all participants played all available games and some participants played individual games more than once. To determine if a correlation existed between the number of games played and post-game play simulation scenario rubric scores or IMMS scores, a Spearman correlation analysis was conducted. Cohen's standard was used to evaluate the strength of the relationships and the results were examined using the Holm correction to adjust for multiple comparisons based on an alpha value of .05. There were no significant correlations between the number of game plays and either the rubric scores or IMMS scores ($p = 1.0000$). A Spearman correlation analysis was also conducted to determine if a correlation existed between the number of games played and the change in time to PPV initiation. Using Cohen's standard and the Holm correction based on an alpha of .05, no significant correlations were discovered ($p = .830$) between the number of games played and a change in time to PPV initiation.

Discussion

Baseline assessments of the participants' neonatal resuscitation knowledge and skill prior to gameplay found high knowledge retention and general performance of the NRP algorithm, likely reflective of the long tenure of the experienced neonatal resuscitation provider participants. However, when the time to initiation of PPV was assessed, participants on average did not initiate PPV until almost seventy-four seconds of life, fourteen seconds later than the evidence-based target of sixty seconds of life. This noted practice deviation from the NRP algorithm is reflective of similar observations of skill decay in the literature (Niles et al., 2017; Shikuku et al, 2018). and serves to confirm the need for frequent refresher training regardless of resuscitation provider level or depth of experience.

During the design phase of the refresher training, motivational design concepts and game-based elements were carefully chosen and applied to align and support the identified learning objectives. Although each game held its own context or story, all games were designed with the same learning objectives, key content, and tasks to be completed. Educators should carefully consider how and when gamification and game elements should be used to engage and motivate learners. The discovery of “new” or “fun” methods to inspire learners can lead educators to overuse or inappropriately apply new learning methods. Rutledge et al. (2018) found that inappropriate application or overuse of game elements as external motivation can amotivate individuals with strong existing intrinsic motivation, cautioning educators to practice the judicious use of gaming elements. In the analysis of the IMMS results, the average game-playing participant selected “mostly true” when asked if the instructional game materials overall were engaging and motivating, validating the use of game-based elements and motivational design in the build of the project’s refresher training.

A technology-based refresher training brought both challenges and opportunities during the design and implementation phases of the project. Most of the project participants are Baby Boomers who were not born into the digital world, but who, as adults, have had to learn and adopt new beliefs and practices in order to navigate this new technology-driven world. Those who were not born and raised in the digital age may be challenged, reluctant, or fearful to accept or adopt technology-enhanced or facilitated training (Kesharwani, 2020), so the project games were built with the Google Docs Editors™ suite, a set of programs commonly encountered in work, education, and personal online environments. The Google Docs Editors™ suite requires the use of the Chrome™ browser, so an initial unanticipated challenge was helping participants know to locate and open the browser on the unit workstation or other device they may have been using. Although in-person, phone, email, or text technical support was offered, there were only four requests for technical assistance. Of the six participants who did not play any games, only one reported at the post-project simulation scenario assessment that they were unable to access the games during the twelve-week period, while the other five participants did not report a reason for not playing. While many who were not born in the digital age have adopted (and continue to successfully adopt) new technology in their work and home life, some may still be unfamiliar, unsure, or apprehensive of education or training that uses a technology-based pedagogy, regardless of available support.

Game access and play were participant-driven, with thirteen of the nineteen participants playing at least one game during the twelve-week period the games were available. When comparing the number of game plays to changes in knowledge scores or time to PPV initiation, those who played two times showed the most improvement in knowledge and in PPV initiation time by 15.4 seconds. Noting participants who played two games also had the highest overall and subscale scores on the IMMS survey while experiencing the greatest improvement in time to PPV initiation, the project results suggest the frequency of the refresher training may be most optimal in terms of engagement, motivation, and skill stabilization when learners complete two events in a twelve-week period. While no statistically significant correlation could be drawn between the total number of game plays and knowledge or skill gain, the observed overall improvement of PPV initiation time towards alignment with the NRP algorithm is both encouraging and meaningful to improving the quality of neonatal resuscitation.

Sample size and demographics contribute to the limitations in the generalizability of the project's results. The homogeneous nature of the project's convenience sample makes the project results and implications difficult to extend to other groups of neonatal resuscitation providers from a more diverse or heterogeneous population. There was also no way to control for the influence of participants' work experience during the project. Participants actively attended births when they were assigned the delivery nurse role, so varied experiential review and actual clinical practice of the NRP algorithm likely occurred and may have confounded the interpretation of project results.

Additional limitations include the potential for design and sampling bias in the project. The investigator was the sole conductor of the pre- and post-game play simulation scenarios. To reduce scoring bias, a standardized scenario scoring rubric adopted from the *Textbook of Resuscitation, 8th Edition* (Weiner & Zaichkin, 2021) was used. The use of a convenience sample from one neonatal unit instead of a randomly selected sample from all of the LPCHS neonatal nurseries may have led to results being biased to reflect the specific characteristics and experiences of that convenience sample. The project also relied heavily on technology and electronic tools, which may have favored those participants who are more familiar or comfortable with accessing or using technology or electronic tools. The investigator selected technology and electronic tools and applications such as SurveyMonkey™ and Google Docs Editors™ suite that are commonly used in the participants' work setting in an attempt to offset identified potential design bias towards the technology-proficient participant.

The results of this project were based on resuscitation knowledge and skill assessments at six weeks post-gameplay. Future research will be needed to determine any longer-term effects or implications of game-based refresher training on neonatal resuscitation knowledge and skill decay and may help to determine the optimal frequency and delivery of such training. Additional future research considerations might also include the use of game-based refresher training to stabilize the knowledge and skill of resuscitation providers in other settings, such as maternity units or small, rural community settings.

Conclusion

Quality neonatal resuscitation is dependent on the resuscitation provider's knowledge of the NRP algorithm and the timely initiation of PPV (Wycoff et al., 2020). Evidence of resuscitation knowledge and skill decay after traditional simulation-based training must be acknowledged and should be the impetus for establishing frequent refresher training that is easily accessible and cost-effective. This project shows promise for future educators as the technology and electronic tools commonly available in the work setting were effectively implemented to create engaging, self-directed games that could be completed during a work shift, avoiding the equipment, supply, and personnel costs associated with traditional, resource-intensive, simulation-based training. Project results noted improved knowledge and performance of the NRP algorithm and a significant reduction of the average time to initiation of PPV in a simulation scenario by 13 seconds. This quality improvement project was successful in demonstrating how an education innovation using existing technology applications and tools can result in a motivationally designed, game-based, resuscitation refresher training solution to ensure the high-quality resuscitation care all newborns deserve.

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Appendix A

Participant Demographics

Participant Demographics

Variable	*n*	%
Gender		
Female	18	94.74
Male	1	5.26
Age in Years		
26-30	1	5.26
36-40	3	15.79
51-55	5	26.32
56-60	5	26.32
61-65	4	21.05
66-70	1	5.26
Highest Degree Attained		
ADN	4	21.05
BSN	13	68.42
MPH	1	5.26
MSN	1	5.26
Years as a Neonatal Nurse		
1-5	0	0.00
6-10	3	15.79
16-20	5	26.32
21-25	1	5.26
26-30	1	5.26
31-35	7	36.84
36-40	2	10.53
On average, how many times a month do you initiate and perform PPV?		
0	1	5.26
<1	2	10.53
1	5	26.32
2	7	36.84
3	2	10.53
4	1	5.26
12	1	5.26

Note. Due to rounding errors, percentages may not equal 100%.

Appendix B

Simulation Scenario Scoring Rubric

Participant ID#________________________ Pre/Post Gameplay Evaluation

Scenario: 30-year-old pregnant mother, gravida 2, para 1, ruptured membranes one hour ago, GBS -, COVID -. Is dilated 8 cm, feeling pressure. **Boldface type** = Evaluator response and actions		
Assess Perinatal Risk: Learner asks the 4 pre-birth questions (1 pt/question)		Score
• Gestational age?	**"39 weeks gestation"**	
• Clear fluid?	**"Amniotic fluid is clear"**	
• Additional risk factors?	**"No additional risk factors"**	
• Umbilical cord management plan?	**"I will delay cord clamping. If the baby is not crying, I'll take a moment to stimulate the baby. If there is no response, I'll clamp and cut the cord"**	
Performs Equipment Check (1 pt/equipment)		Score
• Turns on warmer	Sets to 37.0, uses temp probe	
• Checks suction and oxygen	Sets suction 80-100mmHg, has an 8 and 10Fr suction catheter Turns flowmeter to 10L/min, checks t-piece for pip/peep of 20/5	
• Places blankets, hat, bulb syringe, thermometer, red emergency box within easy reach	All equipment in place	
"The baby is born"		
Rapid Evaluation (1pt/question)		Score
• Does baby appear to be term?	**"Yes, as expected"**	
• Does the baby have good tone?	**"No"**	
• Is the baby breathing or crying?	**"No, not breathing or crying"**	
Evaluator "stimulates" the baby with no response, cuts the cord, and hands the baby to the participant.		

Initial Steps at Radiant Warmer (1pt/step)		Score
● Thermoprotective measures	Dries infant, removes wet linen	
● Stimulates		
● Positions airway	Sniffing position	
● Suctions mouth and nose		
Assess Breathing (1 pt/step)		Score
“Baby is not breathing”		
● Indicates need for PPV		
● Uses standardized process to call for help		
Begins PPV by 60 Seconds of Life (1pt/action)		Score
● Head in sniffing position		
● Correctly applies mask		
● Starts PPV	Time to PPV_______________ Uses 21% FiO2 with PIP/PEEP of 20/5 Rate: 40-60 breaths per minute	
● Request pulse oximeter placement on right wrist/hand		
● Requests cardiac monitor lead placement		
● Within 15 seconds, requests a heart rate check to see if HR rising	**“Yes, heart rate is rising but still below 100”**	
Continues to provide PPV that moves the chest. End scenario after 60 seconds of PPV Total Score (22 points possible):_____		
Adapted from “Positive-Pressure Ventilation: Lesson 4,” in Weiner, G. M. (Ed.). (2021). *Textbook of neonatal resuscitation, 8th ed.*, p. 111-112. American Academy of Pediatrics.		

Appendix C

Instructional Materials Motivation Scale

Instructional Materials Motivation Scale
There are 36 statements in this questionnaire. Please think about each statement in relation to the instructional materials you have just studied and indicate how true it is. Give the answer that truly applies to you, and not what you would like to be true, or what you think others want to hear. Think about each statement by itself and indicate how true it is. Do not be influenced by your answers to other statements.
Use the following values to indicate your response to each item: 1 = Not True 2 = Slightly True 3 = Moderately True 4 = Mostly True 5 = Very True
1. When I first looked at this lesson, I had the impression it would be easy for me.
2. There was something interesting at the beginning of this lesson that got my attention.
3. This material was more difficult to understand than I would like for it to be.
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.
5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.
6. It is clear to me how the content of this material is related to things I already know.
7. Many of the pages had so much information that it was hard to pick out and remember the important points.
8. These materials were eye-catching.

9. There were stories, pictures, or examples that showed me how this material could be important to some people.
10. Completing this lesson successfully was important to me.
11. The quality of the writing helped to hold my attention.
12. This lesson is so abstract that it was hard to keep my attention on it.
13. As I worked on this lesson, I was confident that I could learn the content.
14. I enjoyed this lesson so much that I would like to know more about this topic.
15. The pages of this lesson look dry and unappealing.
16. The content of this material is relevant to my interests.
17. The way the information is arranged on the pages helped keep my attention.
18. There are explanations or examples of how people use the knowledge in this lesson.
19. The exercises in this lesson were too difficult.
20. This lesson has things that stimulated my curiosity.
21. I really enjoyed studying this lesson.
22. The amount of repetition in this lesson caused me to get bored sometimes.
23. The content and style of writing in this lesson convey the impression that this content is worth knowing.
24. I learned some things that were surprising or unexpected.

25. After working on this lesson for a while, I was confident that I would be able to pass a test on it.
26. This lesson was not relevant to my needs because I already knew most of it.
27. The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.
28. The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.
29. The style of writing is boring.
30. I could relate the content of this lesson to things I have seen, done, or thought about in my own life.
31. There are so many words on each page that it is irritating.
32. It felt good to successfully complete this lesson.
33. The content of this lesson will be useful to me.
34. I could not really understand quite a bit of the material in this lesson.
35. The good organization of the content helped me be confident that I would learn this material.
36. It was a pleasure to work on such a well-designed lesson.

Keller, J. M. (2010). *Motivational design for learning and performance: The ARCS model approach*. Springer.