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Rapid Cycle Deliberate Practice and the Zeigarnik-Ovsiankina Phenomenon as a Method of Learning and Achieving Long-term Retention of Airway Management – A Longitudinal Observational Study

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Cover Page Footnote

We would like to extend our heartfelt gratitude to the medical students who served as simulation educators and the Parry Center faculty who spend countless hours dedicated to enhancing the medical education of our future providers at USD SSOM. Without them, this project and its educational benefits would not be possible. Funding was provided by the University of South Dakota Sanford School of Medicine Scholarship Pathways Program and Parry Center for Clinical Skills and Simulation.

Introduction

One of the current goals of medical education in the United States is to graduate physicians that possess the ability to safely and effectively perform certain clinical skills without supervision within the first days of their residency training. The American Association of Medical Colleges (AAMC) created Core Entrustable Professional Activities (EPA) which outline guidelines for clinical skills training to help prepare medical students for residency. According to the AAMC, "This is an important opportunity for undergraduate medical education to develop a new construct toward preparedness and, as an end goal, improvements in patient safety. Ideally, students will perform the core EPAs consistently in situations of varying complexity…" [1]. EPA entrustment is defined as "a judgment by a supervisor or collection of supervisors signaling a student has met specific, defined expectations for needing limited supervision" [1].

Rapid Cycle Deliberate Practice (RCDP) is a simulation-based teaching method that aims to ensure 100% correct and consistent performance of clinical skills and is one method used to prepare medical students to fulfill core EPAs, one of which includes airway management. RCDP was developed by Johns Hopkins University in 2012 and has been widely implemented in healthcare curricula [2]. The distinguishing feature of RCDP is providing immediate feedback to the learner and enabling them to repeatedly practice the skill until mastery is achieved, defined as 100% correct and consistent performance. RCDP can be used for teaching both cognitive and motor skills [3,4].

The Zeigarnik-Ovsiankina phenomenon (ZOP) is a psychological concept that explores the tendency of people to remember uncompleted or interrupted tasks more vividly than completed ones, suggesting that unfulfilled tasks create a state of tension, leading to improved memory retention of the incomplete task details compared to completed tasks [5]. It has been explored in multiple avenues of healthcare, including simulation-based learning, anxiety, and physician burnout [6-9].

The University of South Dakota (USD) Sanford School of Medicine has developed and implemented an RCDP plus Zeigarnik-Ovsiankina phenomenon (RCDP+ZOP)-based airway management and intravenous (IV) induction into anesthesia program for second-year medical students. When a mistake is made during RCDP+ZOP simulation-based training, the facilitator immediately interjects with a correction [10]. Normally during RCDP, when a learner incorrectly recites a step in the sequence, the facilitator waits until the learner has finished to debrief them, instructs the learner to immediately implement the correction, or instructs the learner to regress one step back before implementing the correction [10]. It is less common for learners to be forced to restart the sequence in its entirety during RCDP simulation-based training [11]. Albeit less common, restarting the learning sequence and subsequently forcing an incomplete task may provide a novel learning technique that utilizes the effectiveness of the ZOP while executing RCDP.

In the context of RCDP for medical student endotracheal tube (ET) intubation and IV induction sequence education, leveraging the ZOP could be a strategic approach to enhance learning and skill retention. Implementing the ZOP occurs easily in sequence-driven tasks by intentionally interrupting learners after each mistake and forcing them to restart. This potentially contributes to increased focus attributed to a sense of unfinished business, enhanced memory retention resulting from cognitive tension leading to more memorable experiences, and increased repetitions central to RCDP resulting from more frequent opportunities for corrective actions [12]. Importantly, while it is less common, only RCDP+ZOP methodologies which force learners to restart after each mistake fully leverage the ZOP. Thus, curricula that forces learners to rapidly

repeat a procedure without forcing them to restart are termed traditional RCDP, while curricula that immediately correct and force learners to restart after each mistake are termed RCDP+ZOP. This study aims to compare traditional RCDP simulation-based education (control) to RCDP+ZOP simulation-based education (test) in teaching preclinical medical students ET intubation and the IV induction sequence. Specifically, it evaluates two different types of simulation-based education as the subject of our research and assesses the speed of knowledge acquisition and long-term knowledge retention between students trained with RCDP+ZOP and those trained with traditional RCDP alone. The main goal of this study is to determine if ET intubation and IV induction taught with RCDP+ZOP simulation-based training is more resistant to skills degradation over a six-month period compared to traditional RCDP simulation-based training and debriefing.

Methods

The study design and implementation were approved by the USD Institutional Review Board. Sixty-seven University of South Dakota Sanford School of Medicine (USD SSOM) second-year medical students participated in the Airway Management and IV Induction into Anesthesia Program. Observation and data collection occurred simultaneously during the 2021 – 2022 academic year at the Parry Center for Clinical Skills and Simulation at USD SSOM. The program combined flipped classroom and RCDP methodologies. The flipped classroom consisted of completing reading assignments on airway anatomy and physiology, applied physiology of the central nervous, cardiovascular, and respiratory systems, and pharmacology of the medications used for IV induction into anesthesia. Students used proprietary software developed by USD to learn and self-test the steps of the IV induction and ET tube intubation.

Students were assigned a deidentified course identification number prior to day one. On day one (April 2022) of the activity, students participated in groups practicing IV induction and ET intubation, a nine-step sequence, on low-fidelity task trainers (AirSim Advance with Nasal Passage and Chin, *Parker Medical*). Each simulation took approximately two to eight minutes depending on learners' proficiency. Groups consisted of two learners and one instructor, and each session lasted 40 minutes. All learner groups were split into two cohorts: control and test. The control groups performed the entire procedure regardless of the number of mistakes made, received a debriefing on all mistakes after finishing their attempt, and then repeated the procedure. Test groups performed the procedure until the first mistake was made, received immediate feedback, and restarted the procedure from the beginning. Thus, the control group implemented traditional RCDP teaching and debriefing, and the test group implemented RCDP+ZOP teaching and debriefing. Groups remained the same from day one to day two. In total, 36 participants were assigned to the control group and 31 participants were assigned to the test group.

Depending on the learners' proficiency, they performed a different number of repeated procedures over the 40-minute period. Instructors evaluated learners of both groups in real-time and by objectively recording each step of the procedure as "performed" or "not performed" to reduce subjective evaluation and bias. For each learner, the record included 1) score as a percentage of the maximal score for each procedure, 2) number of procedure attempts per 40-minute period, and 3) average score for the activity. All of day two's (April 2022) activity was conducted in the same fashion. The project required a 2:1 learner vs instructor ratio. Medical Students As Simulation Educators (MSASE) program members were recruited to serve as instructors for day one and two of this course. To ensure consistency in the training administration, all MSASE instructors received a refresher course on the procedure and the assessment technique [4]. Five months after the day two activity, learners were tested for long-term knowledge and skill

retention. The test, labeled as day three (September 2022), was facilitated by clinical faculty to minimize variances between facilitators teaching abilities and used the control group methodology. During day three activity, each learner performed three procedures.

Statistical Analysis

Quantitative variables were grouped according to test and control group designations and followed longitudinally by learners' deidentified course identification number. Paired two-tailed t-tests were used to compare the mean number of incorrect trials until proficiency between groups. Two-way ANOVA was used to compare mean scores between days one, two, and three. Pearson's correlation was used to assess between students average daily score and number of intubation attempts. Importantly, no students were lost to follow-up, although one was absent on day one of training but present on days two and three.

Results

The project's overarching goal was to determine if ET intubation and IV induction taught with RCDP+ZOP simulation-based training was more resistant to skills degradation over a six-month period compared to traditional RCDP simulation-based training and debriefing. The researchers investigated potential correlations between the number of procedures, the degree of short-term and long-term knowledge, and skills retention. The project also investigated correlations between learners' performances on days one and two. Absolute score values in the test group are expected to be lower since the procedure stopped at the first incorrectly performed step, preventing the learner from the possibility of obtaining additional points.

Eligible participants were second-year medical students at USD SSOM. Sixty-seven eligible participants were included in the study. All participants had experience with similar simulation-based learning, but none had participated in ET intubation and IV induction training at USD SSOM.

	Day 1: Control Group n = (36)	**Day 1: Test Group n = (30)**	**Day 2: Control Group n = (24)**	**Day 2: Test Group n=(43)**	**Day 1 vs 2: Control Group (D1-D2)**	**Day 1 vs 2: Test Group (D1-D2)**
Mean # of Incorrect Trials Until Proficiency	1.14	**0.516****	0.333	**0.93****	0.807	-0.414
Confidence Interval	0.845–1.433	0.226–0.806	0.094–0.572	0.674–1.186	-	-
P-Value (T-Test)	0.004		0.001		(n ≠ n)	N/A

** Indicates statistically significant findings of p<0.01

Table 1 Attempts until proficiency achieved

On day one, the test group achieved proficiency in fewer trials than the control group (p = 0.004). The control group required an average of 1.14 (CI = 0.845 – 1.433) trials until proficiency, while the test group needed 0.516 (CI = 0.226 – 0.806) trials, indicating faster knowledge acquisition in the test group during early learning. Conversely, on day two, the control group achieved proficiency in fewer trials than the test group (p = 0.001), with the control group requiring

an average of 0.333 (CI = 0.094 – 0.572) trials and the test group requiring an average of 0.930 (CI = 0.674 – 1.186) trials.

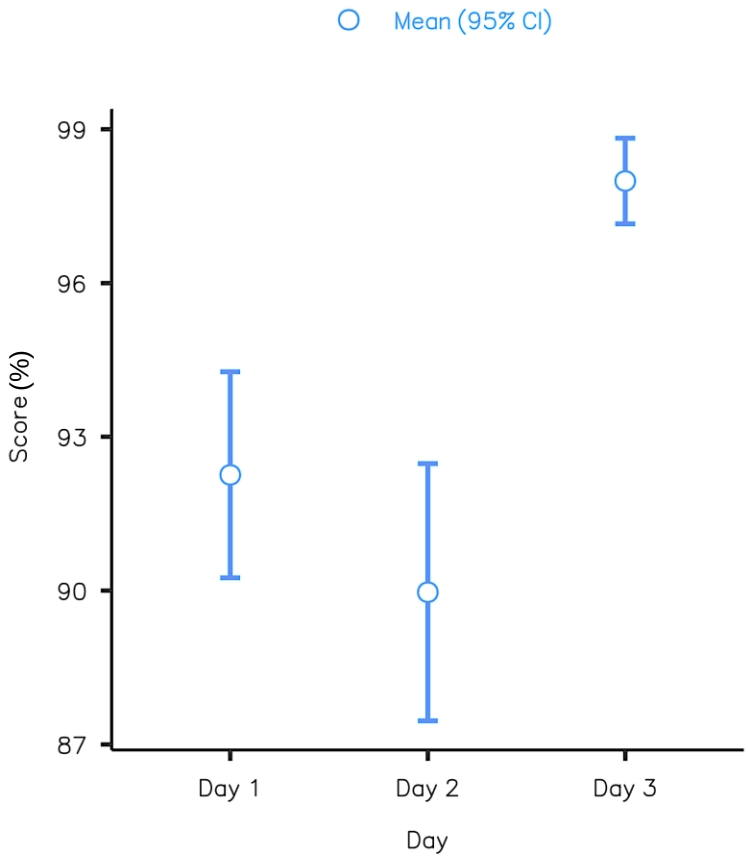

Figure 1 Comparison of daily combined test scores

Test and control groups long-term retention on day three (Figure 1):

Notably, both the test and control groups exhibited a high level of proficiency by the end of the course, demonstrating 98.0% (CI = 0.8%) knowledge and skill proficiency on day three, a significant increase from day one and two scores of 92.3% (CI = 2.0%) and 90.0% (CI = 2.4%), respectively.

Test group day one score vs intubation attempts:

Within the test group, a statistically significant negative correlation was identified between the score on day one and the number of procedures performed on day one ($r = -0.523$, $df = 29$, $p = 0.003$), indicating that students who engaged in a greater number of intubations on day one demonstrated lower total scores for that day. However, there was no significant correlation between the total number of procedures performed on day one and day two and the score on day 3 ($r = -0.072$, $df = 34$, $p = 0.675$).

Day one and day two score and intubation attempts:

There was no significant correlation between the score on day one and the score on day two ($r = 0.111$, $df = 29$, $p = 0.553$), nor was there a significant correlation between the number of procedures on day one and the number of procedures on day two ($r = 0.214$, $df = 29$, $p = 0.247$). However, within the control group, a statistically significant negative correlation was observed

between the score on day one and the score on day two ($r = -0.390$, $df = 34$, $p = 0.019$), indicating that students who excelled on day one performed poorer on day two.

Additionally, there was a statistically significant negative correlation between the number of procedures on day one and the number of procedures on day two ($r = -0.796$, $df = 34$, $p < 0.001$), suggesting that students who conducted more procedures on day one performed fewer on day two.

Discussion

RCDP has previously been effectively implemented in multiple simulation settings that require the learning of either procedural skills or knowledge acquisition [4, 9, 10, 11]. The results of this study suggest that both traditional RCDP and RCDP+ZOP are effective means of teaching integrated procedural skills and knowledge-based sequences together, as evidenced by both the test and control groups demonstrating 98.0% (CI = 0.8%) knowledge and skill proficiency on day three, a significant increase from day one and two scores of 92.3% (CI = 2.0%) and 90.0% (CI = 2.4%), respectively. Thus, both control and test groups demonstrated the same long-term knowledge and skill retention. Better performance on day three vs day two can be interpreted as IV induction knowledge and ET intubation skills internalization occurring as a process of long-term memory that requires time. This is particularly supportive of the work by Gross et. al., who demonstrated successful pediatric airway intubation skills training utilizing traditional RCDP. However, this study also confirms these findings in adult traditional RCDP and RCDP+ZOP simulation-based airway skills training and IV induction sequence knowledge acquisition.

Further, the results reveal that the test group achieved 100% scores on IV induction and ET intubation in fewer attempts than the control group on day one ($p = 0.004$). Conversely, on day two, the test group required more attempts to perform the procedure prior to achieving a 100% score than the control group ($p = 0.001$). These results are striking as they strongly refute the null hypothesis, albeit in opposite directions on day one compared to day two. At face value, this could be interpreted as the RCDP+ZOP positively impacting short-term knowledge and skill acquisition while having a negative impact on mid-term retention; however, similar conflicting interpretations of the ZOP, termed "no universal pattern," exist after a review of numerous studies examining the ZOP [12-14].

The “no universal pattern” observation states that individuals high in need of achievement show better memory of incomplete tasks, whereas individuals low in need of achievement show the opposite [12, 13]. Atkinson continues this explanation: "When the goal is to experience feelings of success and personal accomplishment, then persistence of the interrupted activity in recall and subsequent resumption of it are instrumental to attainment of that goal. When, however, the goal is to avoid feelings of failure, non-recall of past failures and presumably non-resumption of previously failed activities are instrumental to avoiding renewed feelings of failure” [13]. Interestingly, medical students are notoriously motivated by both ambition for personal accomplishment and fear of failure. On day one, students may be predominately motivated by a desire for high achievement due to the psychological safety and appeal of mastering a new task, but on day two, they may be primarily motivated by avoidance of failure resulting from the perceived pressure that students feel to show facilitators that they successfully retained the skills and knowledge that they learned on day one.

The lack of correlation among the number of performed procedures, obtained scores, and long-term retention reveals a delicate balance between deliberate practice and repetition. Deliberate practice and timely and quality feedback are essential factors responsible for learners’ success, albeit in our experience, it is time-consuming, resulting in fewer intubation attempts [10].

Conversely, while increased repetition optimizes intubation attempts, it may result in less intentional practice and suboptimal feedback. Additionally, the ZOP is still a dynamic field of study and may be influenced by the "no universal pattern" observation. As seen in this study, there is a complex relationship between learners' performance and the number of intubation attempts.

While harnessing the ZOP can be beneficial, the overall success of RCDP depends on a balanced approach. The interruptions should be strategically implemented to enhance learning without causing excessive frustration [10]. Additionally, providing constructive feedback during the practice cycles remains crucial for guiding students toward the correct techniques and fostering a positive learning experience, potentially increasing the demands placed on the instructor.

There are multiple limitations of this study. Although the utility of traditional RCDP versus non-RCDP techniques has been shown in the literature, it would be beneficial to have a non-RCDP control group. Additionally, regardless of the refresher course for MSASE instructors, their teaching styles varied significantly. Additional faculty development is required to better ensure consistency in teaching. Further, due to the ambiguous nature of the ZOP "no universal pattern," results are challenging to interpret and generalize.

Conclusion

Healthcare expectations from medical school graduates continue to be demanding. New resident physicians are expected to perform many clinical tasks, skills, and procedures under minimal supervision from attending physicians. ET intubation is a skill that can make for safer medical practice of any healthcare provider if learned correctly. Although simulation-based airway intubation and IV induction are more like the actual practice of medicine than purely cognitive training, they still fall short of fully replicating the nature of intubation and induction. Thus, while imperfect, these results are generalizable to learning the actual practice of airway intubation and IV induction. Both traditional RCDP and RCDP+ZOP are effective teaching methods to produce knowledge and skills that are resistant to degradation over time. RCDP effectiveness relies on timely and quality feedback. The need for more instructors is an inherent challenge of RCDP and there is no clear evidence if RCDP+ZOP is superior to traditional RCDP simulation-based training and debriefing.

Statements and Declarations

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