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Research Article

A Behavior Analytic Approach to Increase Efficiency in a Cadaveric Skills Lab

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Abstract

Introduction: The main objective of this study is to determine what level of prompt salience is needed to decrease the duration of time spent and errors in surgical tools placement while setting up orthopedic surgical instruments on a Mayo stand in a cadaveric skill lab by novel laboratory staff.

Methods: Five novel laboratory staff members were included to reduce retesting effects.

Each participant had limited exposure to the standard operating procedure for surgical tool Mayo stand setup prior to the experiment.

Discussion: Each participant had equivalent experience in the surgical skills lab at the onset of the study. Phase 1 results include high duration and errors in Mayo stand setup. Phase 2 resulted in a significant decrease in both duration of task and errors. Phase 3 maintained the results from Phase 2 with a reduction in errors in tool setup and a significant decrease from Phase 1 in the duration of Mayo stand setup. A decrease of 27 minutes was observed in Mayo stand setup from Phase 1 to Phase 3 prompt salience.

Conclusion: Our study demonstrates that choice architecture addressing surgical tool salience may result in immediate and significant cost savings and cadaveric skills lab surgical workflow efficiency.

Keywords: Orthopedic surgery; Surgical tools; Quality improvement; Behavior analysis; Cadaveric lab; Surgical workflow.

Abbreviations: IRB: Institutional Review Board; SBT: Simulation-Based Training; SOP: Standard Operating Procedure; IOA: Interobserver Agreement.

Introduction

A fundamental pillar of medical training is the foundational education obtained in basic human anatomy, which frequently occurs in a cadaveric skills lab setting [1]. Cadaveric skills labs allow medical students the opportunity for experiential learning. Experiential learning through Simulation-Based Training (SBT) in environments such as cadaveric skills labs has research support for at least six decades [2]. Gordon et al. (2006) highlight the importance of simulated training for medical providers as this allows for the transfer of learning without presenting a risk to patients. SBT allows instructors to provide feedback in a way that is personalized for the student and not in a real-life scenario with patients present. Additionally, SBT allows orthopedic students to form connections between procedural and conceptual knowledge within procedure skill acquisition in a safe environment which allows for error correction without consequences in a work environment [3].

Surtiningtyas (2017) notes that effective instructional design of simulation-based trainings implements authentic tasks that align with genuine problems [4]. A genuine problem facing orthopedic surgeons' medical education is the availability of time for orthopedic students to learn in SBT environments such as cadaveric skills labs. Therefore, an efficient surgical workflow for cadaveric skills is a requirement to optimize the learning experience. However, the professionals supporting the orthopedists in a cadaveric testing facility often do not have direct surgical setting training [5]. They are tasked with setting up surgical instrument Mayo stands to prepare for cadaver surgical training sessions. As surgical instrument cleaning and upkeep are deemed as a high-cost activity, efficiency in the stand setup is a high priority for organizational leaders [6,7]. The accuracy of the setup contributes to the efficacy of the surgical workflow, and errors in this setup require additional resources such as cost and time, as the surgical equipment requires sterilization for infection prevention and safety regulation compliance [8]. This research aligns with the continuous need for efficient and cost-effective practices to support orthopedic surgeons' educational needs [7,8]. Efficiency as a variable in this research will align with past published definitions targeting surgical instrument practices in that the efforts produce a reduction in time spent on activities and costs related to activities [6].

In addition to the time and cost savings, the focus of this study is socially valid due to the interpersonal interactions that occur between the research staff and orthopedic surgeons. As the cadaveric skills lab is a surgical setting, this setting is prone to human errors due to the pressures and stress present [9]. For example, many of the laboratory staff in the cadaveric skills lab are faced with humiliation when errors occur and reduced opportunities to communicate with surgeons regarding error correction [10]. These stressors lead to additional future errors, which waste resources and time for orthopedic surgeons [10].

The Mayo stand plays a key role in the surgical workflow for orthopedic surgeons, even in a cadaveric skills lab setting. When appropriately set up, the Mayo stand facilitates surgical efficiency and streamlines surgical processes. The primary aim of this project was to reduce unwanted variation in the Mayo stand surgical tool setup by manipulating the salience of surgical instruments through choice architecture. Choice architecture has shown success when used to design microenvironments to promote desired behaviors [11]. The choice architecture employs manipulation of item salience in the environment to assist with choice-making when it aligned with behaviors required to effectively identify the correct tools to place on a Mayo stand [11]. The findings of this study will reduce unnecessary sterilization of surgical tools and reduce error corrections required prior to or during cadaveric testing sessions with orthopedic surgeons.

Materials and methods

This research occurred in an orthopedic cadaveric skills lab and included five laboratory staff members without direct training or experience in the cadaveric skills lab. Opportunity sampling was used to identify these five-laboratory staff as they would potentially be tasked with setting up the Mayo stand for future orthopedic cadaveric skills labs but had no training in this task. Institutional Review Board (IRB) approval was obtained, and each participant completed the informed consent process before completing the research tasks.

The research procedures included three phases, with manipulation of the prompt salience through choice architecture across each phase. The initial phase included a surgical equipment peg board and Standard Operating Procedure (SOP) that provided a list of needed surgical tools and a picture of the completed, correct task of a Mayo stand with the required surgical instruments. Two participants completed the research procedures at the phase 1 prompt salience level. The second phase included a higher prompt salience, including a red box outlining the surgical tools on the peg board that were to be placed on the Mayo stand in order and an SOP with a picture of the complete Mayo stand setup. One participant completed the research procedures at this salience level. The third iteration of the choice article included the highest level of prompt salience, and two participants completed phase 3 research procedures. The red box remained around the surgical instruments on the peg board, along with a color code and number for each surgical tool that aligned with the tool placement on the Mayo stand.

During testing procedures, each participant was provided with the SOP and presented the surgical tool peg board. The duration timing started after instructing the participant to set up the Mayo stand, and the timer was stopped when the last tool was placed on the Mayo stand. Errors were scored as any incorrect tool, extra tool, or missing tool on the final Mayo stand.

In addition to the duration and accuracy of tool placement, the investigators calculated the incurred cost per trial in accordance with past research [12]. Stokert and Langerman (2014) found the cost of cleaning and repackaging an individual instrument was $0.10. Additionally, when operating expenses and instrument depreciation per use are added, total processing cost per instrument increases to $0.51 or more [12]. For this experiment, $0.50 was used as the cost per instrument to account for the depreciation of the items in a cadaveric skills lab and published costs aligned with surgical tools to be used on live patients in sterile environments.

Choice architecture salience intervention

During the intervention periods of this research, the salience of the required surgical instruments was increased by introducing environmental changes. First, a designated Mayo stand tool outline was placed on the surgical tool peg board around the required instruments to complete the tasks. The required surgical instruments were inside the box and tools outside of the designated area were not needed to complete the tasks. This manipulation reduced the array of options the novel laboratory staff member was required to scan to find the correct surgical tool. The second environmental variable color-coded both the designated Mayo stand tool and the surgical instruments with the designated Mayo stand placement order. For example, a colored piece of tape was placed on the needed surgical tool, and the tool color on the SOP matched this color. In both salience manipulations, the surgical instruments remained at eye-level to align with research findings supporting proximity and eye-level placement guidelines [11]. Figure 1 presents the choice architecture salience manipulation across the three phases.

Results

Phase 1: Two participants with no prior experience in the cadaveric skills lab completed Phase 1 Salience Intervention. They were provided with task instructions, and duration and errors were measured. Participant one completed the Mayo stand setup in 36 minutes and had four errors in surgical instruments. Participant 2 completed the task in 22 minutes and had four errors in surgical instruments. After data analysis, the need for additional salience was evident due to the long duration and errors.

Phase 2: The same research procedures occurred in Phase 2. However, the salience of the surgical instruments was increased by creating a red box around the Mayo stand instruments to be placed on the stand. One participant with no prior experience in the cadaveric skills lab completed the research procedures. The participant completed the task in one minute with no errors. However, the participant anecdotally reported he was unsure of his accuracy and would be hesitant to present the completed Mayo stand to an orthopedic surgeon. Due to the anecdotal feedback, the researchers increased the salience again.

Phase 3: Two participants with no prior experience in the cadaveric skills lab completed Phase 3 research procedures. The prompt salience was increased by adding color-coded numbering to the surgical instruments that aligned with color coding on the Standard Operating Procedure in addition to the box outlining the required tools on the peg board. Both participants completing Phase 3 with the salience intervention in place completed the Mayo stand setup in two minutes and made zero errors.

Figure 2 presents a graphic display of the participant duration and error data across phases.

Organizational cost

The cost for the instrument cleaning and minutes spent on task in the cadaveric skills lab was adjusted from published operating room costs as the cadaveric skills lab does not require a sterile environment. Costs published in the literature were identified as the lowest published cost for instrument cleaning and cost per minute reported [7]. The cost per error was $0.51 and the cost per minute in the cadaveric skills lab was adjusted to $20.00. Phase 1 costs averaged to $582.04. Phase 2 had the lowest cost of $20.00. Phase 3 costs averaged to $40.00 per Mayo stand setup. The cost reduction of the average cost of the Mayo stand setup from Phase 1 to Phase 2 was a 96.56% reduction. The cost reduction of the average cost of the Mayo stand setup from Phase 1 to Phase 3 was a 93.13% reduction. Table 1 summarizes these results and change across phases.

Validity

Two independent trained data collectors collected duration and accuracy data for each observation during this research. Interobserver Agreement (IOA) was calculated for both accuracy and duration. High IOA was maintained (100% for both accuracy and duration) throughout research procedures, supporting the validity of the results.

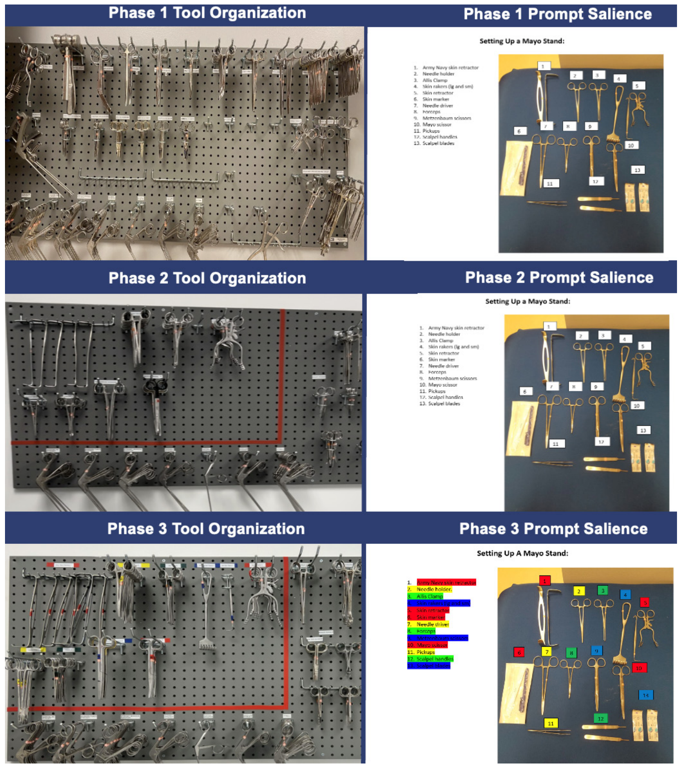

Figure 1: Choice architecture salience manipulation across the three phases.

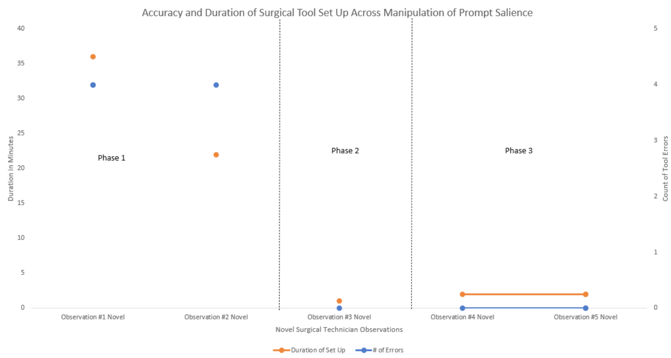

Figure 2: Duration in minutes and errors in Mayo stand setup per participant and across phases.

Table 1: Cost per phase and phase cost comparison to Phase 1.

Participant #	Error cost ($0.51/Error)	Time cost ($20/1-minute)	Total cost
Phase 1			
#1	$2.04	$720	$722.04
#2	$2.04	$440	$442.04
Phase 2			Δ-96.56%
#3	0	$20.00	$20.00
Phase 3			Δ -93.13%
#4	0	$40.00	$40.00
#5	0	$40.00	$40.00

Note: Δ- Change in average cost of Mayo stand setup compared to average cost of Phase 1 Mayo stand setup.

Discussion

The choice architecture manipulations used in this research increased the salience of surgical tools to complete the setup of a Mayo stand in an orthopedic cadaveric skills lab, reducing costs by 93.13% and reducing errors to an acceptable level per the organization's Standard Operating Procedure. Healthcare operation costs have continued to rise over the past 2 decades and continue to rise at an alarming rate [7]. Research has shown that small changes in surgical workflows can have a meaningful effect on operating costs for surgical centers, which can be generalized to a cadaveric surgical skills laboratory [7]. In this study, we successfully manipulated the salience of surgical tools to increase the accuracy of surgical tool placement on a Mayo stand for novel participants, which increased the overall efficiency of the cadaveric skills lab.

Some surgical centers report reprocessing costs per instrument as low as $0.51 and as high as $3.19 per instrument [7]. Therefore, the generalizability of the findings of this study is profound and may be utilized across many organizations and have significant cost reduction effects. As the choice architecture manipulations were low cost and easily implemented, the intervention can easily be adjusted for multiple settings to decrease operation costs and increase operational efficiencies.

Additional endpoints not directly measured during the study is the reduction in workload experienced by the laboratory staff. As the errors in tool placement were reduced, the steps required for error correction were removed from the laboratory staff workloads. Additionally, the stressors experienced when errors occur in the surgical workflow were removed from the environment [9,10]. Although not directly measured during the study, participants anecdotally reported a reduction in stressors with the final salience manipulation.

Limitations are present within this study. As novel laboratory staff were included, this led to a small sample size. However, with such a clear difference observed during data analysis, this limitation was mediated. Additionally, this research occurred at a single institution. Mayo stand setup varies across institutions, and this variation in setup was not captured in this study's procedures. Future research could test the increased prompt salience used in Phase 3 in various Mayo stand setups to determine if the same decrease in errors and set-up time is observed across different instrument sets.

Conclusion

Our study demonstrates that choice architecture addressing surgical tool salience may result in immediate and significant cost savings and cadaveric skills lab surgical workflow efficiency.

Author declarations

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