Effectiveness of Educational Modules to Increase Knowledge of Operating Room Fires in Student Registered Nurse Anesthetists

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Abstract

Background and Review of Literature: Operating room (OR) fires can inflict devastating harm to healthcare organizations, staff, patients, and caretakers. All perioperative staff members need specific education on preventing and managing OR fires. Student registered nurse anesthetists (SRNAs) should receive thorough fire prevention and management training during their didactic training before entering clinical rotations to increase patient and staff safety. Purpose: This is a project aimed to determine if implementing an electronic OR fire training module would increase the knowledge and confidence of first-year SRNAs attending a small private Catholic university in the mid-west before heading into their clinical rotations. Methods:81 research articles concerning current knowledge and education in OR fires were analyzed. Implementation Plan/Procedure: A pre-education intervention assessment questionnaire was completed to establish a knowledge baseline. A module was developed to provide critical education on OR fire safety, in which 34 SRNAs participated in the project. A post-education assessment questionnaire revealed increased knowledge and confidence in OR fire prevention and management. The SRNA participants also completed a modified Educational Practices Questionnaire-Curriculum Likert-scale tool that allowed them to give feedback to the course presenters regarding whether their educational needs were met. The sample population size of only 34 participants limits the interpretation of the results. Further

investigation into using electronic training modules to increase knowledge and confidence should be explored.

Keywords: operating room, surgical, safety, and fire

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Section I. Introduction

Effectiveness of Educational Modules to Increase Knowledge of Operating Room Fires in Student Registered Nurse Anesthetists

Operating room (OR) fires can result in devastating outcomes for staff and patients. Approximately 550 to 650 OR fires occur yearly in the United States, but occurrences may be significantly higher because only 50% of states have mandatory reporting requirements (Clarke & Bruley, 2012). Although OR fires are infrequent, knowledge of the proper management and prevention techniques is critical. Certified registered nurse anesthetists (CRNAs) are best positioned to prevent and manage OR fires because they administer more than 50 million anesthetics per year, and most fires occur in the airway, the anesthetists' area of expertise (American Association of Nurse Anesthesiology [AANA], n.d.). As future CRNAs, student registered nurse anesthetists (SRNAs) represent the ideal population to improve patient safety regarding OR fire knowledge. Additionally, a solid understanding of the prevention and management of OR fires will decrease the response time to extinguish the fire when every second matters.

Background

OR fires can lead to adverse outcomes such as burns, infection, inhalational injuries, disfigurement, and death. Other complications associated with OR fires include prolonged hospital courses, psychological trauma, cancellation of surgery, and increased hospital resource use. (Apfelbaum et al., 2013). In addition, OR fires are an increasing source of liability for anesthetists, with fire-related surgical anesthesia claims increasing from less than 1% in 1985 to 4.4% by 2009 (Mehta et al., 2013). Of note, 83% of fires occurred during monitored anesthesia care (MAC) for procedures of the head, neck, and upper chest, while 17% occurred during

general anesthesia, usually due to an endotracheal tube cuff leak (Mehta et al., 2013). The perception of the possibility of an OR fire decreased in the late 1970s with new volatile anesthetics that were less explosive and flammable (Nagelhout, 2018). However, despite these new adjuncts of anesthesia, surgical fires remain a real danger in today's OR (Nagelhout, 2018). Therefore, the attitudes of OR staff towards OR fires remain an important consideration in the preparedness to manage a surgical fire (Cho et al., 2022).

Case studies and prospective experimental design studies have been utilized to help guide the movement toward OR fire prevention. However, much of this exploratory research investigating oxygen delivery devices has demonstrated a very real cause for concern regarding OR fire risks. For example, even laser-resistant endotracheal tubes can be prone to ignite and cause an airway fire at temperatures produced by lasers and electrocautery in the presence of supplemental oxygen. In addition, these studies have shown a significant issue regarding significant oxygen leaks to closed airway systems when laryngeal mask airway devices are used in children. Finally, even though studies have experimented with different surgical draping techniques and the use of scavenging devices to reduce the oxygen concentration in the OR, the surgical drapes and sterile gowns tested by the Consumer Product Safety Commission do not meet requirements for flammability in oxygen-enriched environments (Tola et al., 2018).

In 2008, the Joint Commission established OR fire reduction as the 11th National Patient Safety Goal and identified knowledge deficit as a contributing factor to OR fires (The Joint Commission, n.d.). Despite increased emphasis by the Anesthesia Patient Safety Foundation, many CRNAs are still unaware of the risks of an OR fire (Mehta et al., 2013). CRNAs and SRNAs have self-reported knowledge deficits in fire risk assessment and management, exacerbated by a lack of interest in this important topic that requires urgent intervention (Coletto

et al., 2018). To confront this shortcoming, effective communication regarding OR fire risk acknowledgment among all surgical team members is necessary (Tola et al., 2018). Coletto et al. (2018) suggest education should be the first step toward addressing this deficit. Furthermore, the Association of Perioperative Registered Nurses has taken a stand against OR fires and is playing a leading role in patient safety and education for preventing surgical fires. Their guidelines depict fire safety practices, including all possible components to the fire triangle, and focus on clear communication among staff and using a fire risk assessment tool during the surgical time-out (Tola et al., 2018).

Problem Statement

OR fires are a preventable problem that impacts patient safety, and CRNAs are in the most influential position to prevent and manage them. Unfortunately, SRNAs have a knowledge deficit in OR fire risk and management. Thus, they are the ideal population to target to influence the future of effective OR fire prevention and management. This knowledge deficit led to the following PICOT question: In Marian University SRNAs graduating in 2025, does the institution of an E-learning module on OR fires increase knowledge? To investigate this question, pre-module test results will be compared to post-module results to determine if knowledge was significantly increased. Expanding the knowledge of SRNAs regarding OR fire prevention and management can address the increasing incidence of OR fires and knowledge deficits among SRNAs surrounding OR fires.

Needs Assessment & Gap Analysis

Marian University currently addresses OR fires during NSG 611: Anesthesia Principals II using PowerPoint lecture to cover chapter 47: Anesthesia and Laser Surgery in Nurse Anesthesia by Nagelhout. However, current evidence reflects that CRNAs and SRNAs report a knowledge

deficit in this area (Coletto et al., 2018). While the best practice to increase knowledge in SRNAs has not been determined, traditional textbook and lecture strategies have not successfully addressed this issue. Therefore, Marian University's nurse anesthesia program represents an opportunity for an OR fire E-learning module to improve SRNA knowledge.

Project Aims and Objectives

This project aimed to determine if electronic learning modules increase OR fire management and prevention knowledge amongst first-year SRNAs in a nurse anesthesia program in the mid-west. While OR fires may be considered a rare occurrence in the field of anesthesia, the outcomes can be devastating to the patient and providers both physically and mentally. The purpose of this project was to determine if a change from the current OR fire prevention and management education improves the knowledge and skill sets of first-year SRNAs and increases their overall confidence heading into clinical. An electronic learning module was completed following an anonymous pre-test survey questionnaire, and the results were compared to a post-test questionnaire. The survey questionnaire consisted of quantitative questions regarding OR fire management and prevention and six Likert scale ranking questions. The expected outcome was that most SRNAs from the nurse anesthesia program in the mid-west would demonstrate increased survey scores between the pre-test and the post-test and exhibit an increase in confidence ranking after the online education modules.

Section II. Theoretical Framework

Theoretical Framework

The Iowa Model developed at the University of Iowa Hospitals and Clinics in the 1990s to guide research and improve patient care will be the theoretical framework for this research project (Iowa Model Collaborative, 2017). (See APPENDIX A). This model guided the process

of identifying the current knowledge gap issues surrounding OR fires, research solutions, and implementing changes. The model is a step-by-step guide that starts with identifying a trigger or issue. This step is followed by examining the priority level of the problem, forming a research team, and assembling, appraising, and synthesizing research (Iowa Model Collaborative, 2017). Once sufficient evidence has been acquired, an implementation plan will be developed with baseline data collected and compared to post-pilot data to determine if the change is appropriate for adoption into practice (Iowa Model Collaborative, 2017).

The Iowa Model was used to guide this project by determining the issue of first-year SRNAs feeling underprepared regarding the management and prevention of OR fires as they transition into clinical as junior students with the current OR fire education in the curriculum. After many discussions with classmates regarding their confidence regarding OR fire knowledge, feeling underprepared was deemed an issue. Despite the rarity of OR fire occurrence, the devastation that ensues due to a lack of fire management and prevention knowledge makes it a high-level priority. As a result, a project team was developed comprised of two junior-level SRNAs, a chair, and a board member. The implementation portion of this project will include an E-learning module subjected to a small sample population consisting of first-year SRNAs at a private Catholic University in the Midwest. This project aimed to determine if the intervention would statistically improve knowledge and confidence among the sample population. Based on the study's results, it will be decided if the E-learning module should be integrated into the university's curriculum during the first year of didactic before transitioning into clinical.

GANTT Chart

See APPENDIX B

SWOT Analysis

Key stakeholders in this project include first-year SRNAs and the patients who will benefit from safer, more knowledgeable anesthesia providers. This project's strengths include using electronic educational and survey material to increase the ease and convenience of completion and academic support from the program director. Additional strengths include the project chair being an anesthesia principles professor from the university who is well-versed in academic question design and development to assist in the survey questionnaire development. Weaknesses of this project proposal include a small sample population that may not represent the larger population. Additional barriers include limited responses from first-year participants who receive no rewards for participation. Opportunities for this project include increased knowledge and confidence for first-year SRNAs as they begin clinical rotations. Threats to this project include the willingness of students to participate in the E-learning course and the potential for students to miss key their anonymous ID numbers between the pre-test and post-test, making it difficult to compare data using paired t-tests. A table outline of the SWOT analysis can be seen in APPENDIX C.

Methods

This literature review was conducted to examine articles concerning operating fire safety. The review was performed using the keywords *operating, room, surgical, safety,* and *fire.* This review was conducted in November 2022 using the databases Medline-Ebsco and PubMed. The database searches were performed using the BOOLEAN phrases *operating room,* AND *fire, AND safety,* OR *surgical fire*. The 81 database search results were reduced to exclude duplicates, articles not written in English, and articles published greater than five years ago, resulting in 24 research articles as shown in a PRISMA flow chart (Appendix D). Inclusion criteria was used to

reduce the remaining articles further. The inclusion criteria consisted of articles reporting on operating room or surgical fire and safety and articles published over the past five years, excluding class studies. Articles that did not primarily investigate operating room or surgical fires and safety were excluded. After consideration, 11 articles and other sources were included in the literature review.

Results

81 articles were initially retrieved from the literature review. After applying inclusion and exclusion criteria, the literature review yielded 11 articles. A PRISMA flow chart in Appendix E shows the inclusion and exclusion criteria. The 11 articles included two expert opinion articles and guidelines, two cross-sectional studies, six experimental studies, and one prospective cohort study. None of the studies reported theoretical frameworks to guide research. Of the final articles that included sample sizes, there were 11 articles comprising a total sample size of 589 with a range of 7 to 170 participants. These studies were conducted in the United States and Korea. The literature review matrix includes specific information about each study, shown in Appendix E.

Current Knowledge

The OR fire triad is a major area of focus among current literature on OR fire knowledge (Apfelbaum et al., 2013; Chavis et al., 2016; Cho & Hwang, 2022; Coletto et al., 2018; Culp & Muse, 2021; Davis et al., 2018; Fischer, 2015; Flowers, 2004; Samuels et al., 2020; Tola & Graling, 2018; & Troung, et al., 2022). The triad that enables an OR fire to occur includes an ignition source, fuel, and an oxidizer (Chavis et al., 2016). The most common ignition source is electrocautery and lasers (Chavis et al., 2016; Coletto et al., 2018; Culp & Muse, 2021). The most common oxidizer is supplemental oxygen, but nitrous oxide can also serve as a source, and the most common fuel is the surgical drapes and dressings, but it can also include hair (Coletto et

al., 2018). Team members all have a role in controlling the fire triad, where generally, the surgeon is in control of the ignition source, the anesthesia provider handles the oxidizer, and the OR nurse controls the fuel (Chavis et al., 2016; Coletto et al., 2018)

Most surgical fires occur during MAC sedation because there is frequently an unprotected oxygen source, such as a nasal cannula (Samuels et al., 2020; Tola & Graling, 2018). Most fires occur during outpatient procedures, where MAC anesthetics are more common (Samuels et al., 2020; Tola & Graling, 2018). Procedures above the xiphoid process are considered a higher risk for a fire (Tola & Graling, 2018). Effective communication and the fire risk being addressed during a surgical time-out have been identified as guidelines that help reduce fire risk (Davis et al., 2018; Samuels et al., 2020).

Education

Due to the rarity of OR fires, educational programs tend not to emphasize fire safety and prevention (Culp & Muse, 2021). Four of the 11 articles selected for review employed an educational intervention or a pre-intervention knowledge assessment compared to a post-intervention assessment (Chavis et al., 2016; Fischer, 2015; Tola & Graling, 2018; & Troung et al., 2022). Education has been identified as a useful means to increase knowledge regarding OR fires, prevention, and management (Chavis et al., 2016; Fischer, 2015; & Troung et al., 2022).

Chavis et al. (2016) specifically utilized an e-learning module to implement education and found an increase in knowledge from 12.2% to 26.8%, a 14.6% increase. Knowledge retention was also measured over time, and 90 days later, knowledge was found to be 31% (Chavis et al., 2016). Another study employed a 50-question pre-test and post-test to measure fire prevention knowledge in ten anesthesia providers after implementing an educational course (Fischer, 2015). A satisfactory score on this test was 85%, and none of the participants achieved

this, with an average score of 66.60. The average post-test score was 92.80 and showed a statistically significant increase in knowledge with a p-value of 0.001 (Fischer, 2015). Troung et al. (2022) measured the confidence of OR staff in managing an OR fire before and after education and simulation-based intervention. 180 OR staff participated, and 86% reported feeling more confident if an OR fire did occur (Troung et al., 2022).

One of the four studies that examined the effectiveness of an educational intervention on OR fire knowledge found that gains in knowledge from the intervention were insignificant (Tola & Graling, 2018). Tola and Graling (2018) utilized a 27-question pre-test and post-test to assess fire safety knowledge, fire prevention, and surgical fire management. The average percent correct on the pre-test was 48.82% compared to 71.88% post-test, which was insignificant, with a p-value of 0.22 (Tola & Graling, 2018).

Section III. Project Design

Development of a Curriculum

This project aims to improve the educational practices pertaining to OR fire prevention and management to prepare SRNAs better as they transition into clinical practice to promote patient and staff safety. An E-learning module was developed using the university's current learning management system to improve SRNA knowledge and confidence in OR fires. A quantitative methods design using pre/post-tests was developed. This method design will allow for the direct comparison of data results to determine if the educational intervention successfully increased OR fire knowledge. The assessment and evaluation of the outcomes will be used to determine if a change to the current curriculum is warranted.

Project Site and Population

This project was implemented at a private liberal arts university in the Midwest United States. On average, the DNP nurse anesthesia program admits 32 students per cohort every year. The structure of the DNP nurse anesthesia program is heavily frontloaded with a didactic course load during the first four semesters and backloaded with more clinical focus during the remaining five semesters of the program. Additionally, the course structure is split between hybrid online and in-person classes. Several academic faculty are remote, out of state, and teach online courses via a video chat streaming service. Simulation training begins in semester three and runs through the end of semester five.

Currently, the only mention of OR fires in this program's course structure is confined to one PowerPoint presentation slide regarding ears, nose, and throat surgery in an anesthesia principles course. Furthermore, the current structure of the simulation training does not include any OR fire prevention and management scenarios to challenge and prepare the SRNAs as they transition from didactic to clinical practice.

The target population for this capstone project included all first-year SRNAs from a private liberal arts university's spring class of 2025. These SRNAs were currently in their anesthesia principles courses and had not yet learned about OR fire prevention and management. Those SRNA students from the program who are not part of the 2025 class were excluded. The researchers have witnessed a lack of clinical preparedness regarding OR fire safety in the previous cohorts and aimed to improve educational processes at the university.

Project Team

In the spring of 2023, two SRNA students collaborated to develop an E-learning module on OR fire prevention and management. The team consisted of two SRNAs and a clinical CRNA faculty member who served as the project chair and provided validation for the knowledge

assessment questionnaire tool that was utilized. The two SRNAs developed the knowledge assessment tool using anesthesia textbooks from the National Certification Examination bibliography, administered pre and post-test surveys and interpreted the results.

Methods and Measurement Instruments

A pre/post-test survey questionnaire addressing the knowledge and confidence rating of OR fire prevention and management was utilized for this project. Using Qualtrics software, two questionnaires were created for the SRNAs to complete, consisting of entry-level to advanced-level questions. Two program faculty members reviewed the questions for face validity and content validity. Both questionnaires consisted of 11 questions, including multiple-choice, select all that apply, true and false, and one Likert scale confidence ranking question. The post-test includes teaching effectiveness questions developed using the Educational Practices Questionnaire-Curriculum (EPQ-C) retrieved from https://www.nln.org/education/teaching-resources/tools-and-instruments. Please see appendix (F) for the pre-test and appendix (G) for the post-test intervention questionnaire. Please see appendix (H) for the complete tool Educational Practices Questionnaire-Curriulum (EPQ-C). See appendix (I) for the modified (EPQ-C) tool utilized for this project.

Data Collection Procedures

In March of 2023, an email was sent out to SRNAs from the class of 2025 containing a link to the pre-test knowledge questionnaire, E-learning module, and post-test knowledge questionnaire. The knowledge assessment questionnaires were developed using Qualtrics survey software. Students were asked to complete the pre-test questionnaire prior to viewing the E-learning module and then complete the post-test questionnaire after the learning module was completed. Survey questions remained the same from the pre-test to the post-test, with five EPQ-

C Likert scale questions added to the post-test. Students were granted seven days to complete all components of the project, at which time they received an email thanking them for their participation. No student information was collected during this project. Students were asked to use the last four digits of their student ID to maintain anonymity while allowing researchers the ability to match and compare each student's pre/post-test results.

Ethical Considerations

Internal Review Board (IRB) approval was obtained before initiating this DNP project. This project contained no participant identifiers. Data was stored in an encrypted file on the researcher's personal laptop. Only direct members of the DNP project, including the researchers, chair, and project mentor, had access to the data. Data collection results were stored for 24 months when all project data was destroyed. Participants were all SRNAs from the private liberal arts university who were engaged in their didactic workload. All participants voluntarily participated in the project, and no financial incentives, risks, or punitive actions were taken against those who did not participate.

Minimal risk to participants was expected and identified as risks related to the stress of using an E-learning module for educational purposes. The identifiable risk fell within the expected risk for all other educational structures of the university. Participants maintained confidentiality by using the last four digits of their student ID instead of their names. In addition, the Qualtrics software assisted in preserving data results' anonymity. An informed consent document was dispersed to the participants, explaining the key elements of the research project and what their participation in that project resembles, including the potential risks and benefits to participants. Furthermore, all researchers satisfactorily completed the Collaborative Institutional Training Initiative Modules pertaining to the conduction of responsible research.

Project Evaluation Plan

Data results were collected utilizing Qualtrics software. The statistical measurement test employed in this project was a paired t-test. Pre-test and post-test were compared to determine if the two questionnaires had significantly higher score averages. The same pre-test and post-test surveys were used, with the exception of the five additional EPQ-C questions on the post-test questionnaire, to maintain consistent measurements. Descriptive statistics were gathered and compared between both samples. Inferential statistics using a paired t-test were analyzed and reported on. In this project, the test score was the dependent variable, and the E-learning module was the independent variable. The level of measurement for the results was interval. The data analysis program utilized for result testing was Excel.

Section IV. Data Analysis and Results

Results

Prior Student Training on OR Fires

32 SRNAs participated in this DNP project from start to finish. All SRNAs reported having no prior training in preventing or managing OR fires. All of the participating SRNAs were currently first-year students before entering into clinical rotations.

Student Participation

32 SRNAs (100%) of the first-year cohort participated in this quality improvement project, which included completing a pre-test knowledge survey, an E-learning module, a post-test knowledge survey, and the modified EPQ-C assessment tool. Demographic data, including gender, age, and race, were not collected as they were deemed irrelevant to the project.

Student Self-Confidence

A comparison between the pre-test and post-test confidence ranking questions revealed a shift from 87.5% of participants feeling extremely and moderately unconfident to 83.1% feeling confident to moderately confident. The scale was as follows: 1= Extremely Confident, 2= Moderately Confident, 3= Confident, 4= Moderately Unconfident, 5= Extremely Unconfident. The median Likert scale value for the pre-test was five (extremely unconfident). The median value for the post-test was three (confident). A paired t-test revealed a statistically significant difference ($p<0.001$) between SRNAs pre-test confidence and their post-test confidence. See Table 1 for results on self-confidence between the pre-test and post-test.

Table 1

t-Test: Paired Two Sample for Means		
	Pretest	*Post test*
Mean	4.5	2.84375
Variance	0.516129032	0.394153226
Observations	32	32
Pearson Correlation	0.750958467	
Hypothesized Mean Difference	0	
df	31	
t Stat	19.415596	
P(T<=t) one-tail	<0.001	
t Critical one-tail	1.695518783	
P(T<=t) two-tail	<0.001	
t Critical two-tail	2.039513446	

Student Knowledge

All 32 participating SRNAs reported having no prior OR fire prevention and management training. A pre-test was administered before any education intervention. A systematic analysis of each question revealed a low of 3.13% (question 7) and a high of 75% (question 5) in correctness from respondents. The post-test analysis displayed a low of 25% (question 9) and a high of 100% (questions 3,4,11,12). See Appendix F for pre and post-test questions. A paired t-test was

also conducted, determining a statistical significance between the two samples ($p < 0.001$). See Table 2 for results on SRNA knowledge from the pre-test to the post-test.

Table 2

t-Test: Paired Two Sample for Means		
	Pretest	*Post-test*
Mean	36.88%	79.38%
Variance	0.05984813	0.09574833
Observations	10	10
Pearson Correlation	0.60461899	
Hypothesized Mean Difference	0	
df	9	
t Stat	-5.3097115	
P(T<=t) one-tail	<0.001	
t Critical one-tail	1.83311293	
P(T<=t) two-tail	<0.001	
t Critical two-tail	2.26215716	

Educational Practices Questionnaire-Curriculum (EPQ-C) Analysis

The Educational Practices Questionnaire-Curriculum tool was modified with permission from the National League for Nursing to allow participants to evaluate aspects of the E-learning in regards to meeting their educational needs. This tool consisted of five Likert-style questions. The scale was as follows: 1=strongly disagree with the statement, 2= disagree with the statement, 3= neither agree or disagree, 4= agree with the statement, 5= strongly agree with the statement. The results range was as follows: 1-1.8=Strongly Disagree, 1.9-2.6= Disagree, 2.7-3.4= Neither agree or disagree, 3.5-4.2= Agree, 4.3-5= Strongly Agree. See Table 3 for the analysis of the EPQ-C tool.

Table 3

Educational Practices Questionnaire-Curriculum (EPQ-C)	Average		Interpretation
Q1 - I had an opportunity to learn how to apply course concepts to future real-life experiences.	3.55		Agree
Q2 - Using learning experience activities made my learning more productive.	3.95		Agree
Q3 - I could complete the coursework in a reasonable amount of time.	4.16		Agree
Q4 - The objectives for the learning experience were clear and easy to understand.	4.39		Strongly Agree
Q5 - The learning experience offered a variety of ways in which to learn the material.	4.18		Agree

Section V. Interpretations and Limitations

Interpretations of Findings

In this education interventional study, an OR fire e-learning module resulted in significantly higher test scores than baseline ones. The learning module also resulted in a significant change in student self-confidence in OR fire prevention and management. In addition, a curriculum analysis tool was used, which revealed the module was, on average, able to meet the learning needs of the 32 participants.

Further investigations would be valuable in determining how OR fire education is addressed in the remaining 123 nurse anesthesia programs in the U.S. and comparing knowledge assessments to broaden the analysis of the effectiveness of our e-learning module. The significant results of our study suggest that future research should focus on the generalizability of our findings. Another area for future research to explore is the effectiveness of an e-learning module versus simulation education or the effect of combining both modalities. The results of our study could have implications for practice in anesthesia and in the OR. For example, our intervention was effective in students, but e-learning modules may be able to be used in hospitals to educate employees to increase knowledge, confidence, and preparedness.

Limitations

Some limitations of this study should be considered. First, it was relatively underpowered to conclude generalizability, with only 32 participants. A larger study would help with the

relevance of our findings. Second, follow up with participants to determine the retention of knowledge confidence and examine if a lasting impact was not feasible. Finally, the knowledge test included 11 questions that could be underpowered to extrapolate a true knowledge change. However, including a self-confidence assessment component aimed to negate this issue, and the study can serve as the basis for further investigations appropriately designed to assess lasting knowledge change.

Section VI. Conclusions

Conclusion

OR fire safety and training is an essential piece of education that needs to be emphasized early in the SRNA's didactic workload. Incompetence related to OR fire prevention and management can have deadly consequences for our patients. Despite the relatively low reported occurrence of fires in the OR nationally, all perioperative staff members must do their part to reduce fire risks.

This project was designed to determine the implications of implementing an electronic learning course to increase SRNA knowledge and confidence as they head into their clinical rotations. Prior OR fire education at this particular university was deemed insufficient amongst previous cohorts. An in-depth module was created and included a descriptive PowerPoint, ASA fire safety algorithm, videos, and case studies to allow the learners multiple ways to receive the information.

An analysis of the data revealed a statistically significant improvement between pre-test knowledge and pre-test confidence ratings compared to the post-test knowledge and post-test confidence ratings. These findings reiterate the need for the university to implement a more

advanced OR fire education module to the current didactic regimen. Moving forward, the university could add this OR fire educational module to their anesthesia principals' materials to better prepare their students for clinical practice.

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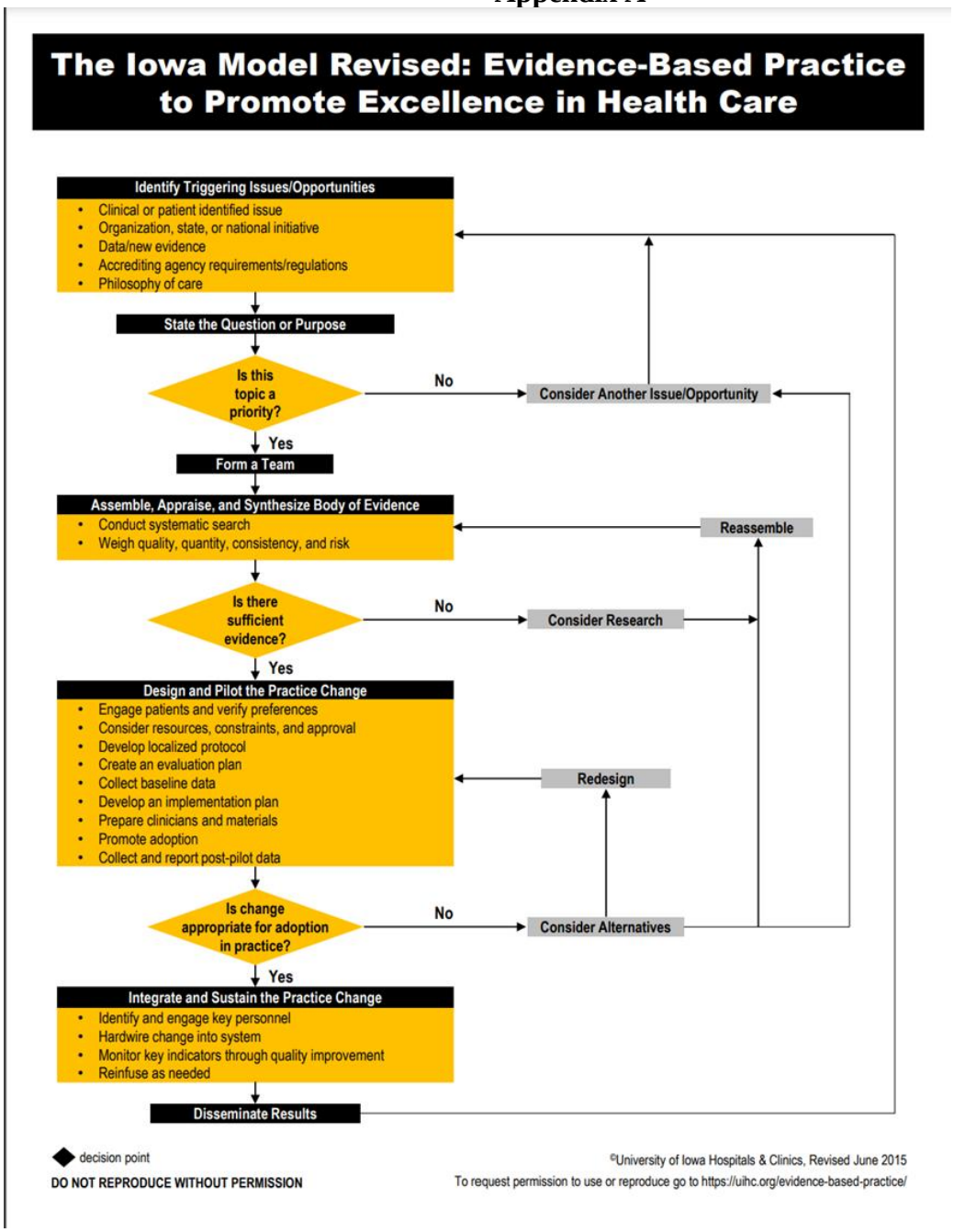
Truong, H., Qi, D., Ryason, A., Sullivan, A. M., Cudmore, J., Alfred, S., Jones, S. B., Parra, J. M., De, S., & Jones, D. B. (2022). Does your team know how to respond safely to an operating room fire? Outcomes of a virtual reality, AI-enhanced simulation training. Surgical Endoscopy, 36(5), 3059–3067. https://doi.org/10.1007/s00464-021-08602-y

Appendix A



Iowa Model Collaborative. (2017). Iowa model of evidence-based practice: Revisions and validation. *Worldviews on Evidence-Based Nursing, 14(3), 175-182. doi:10.1111/wvn.12223*

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Appendix B

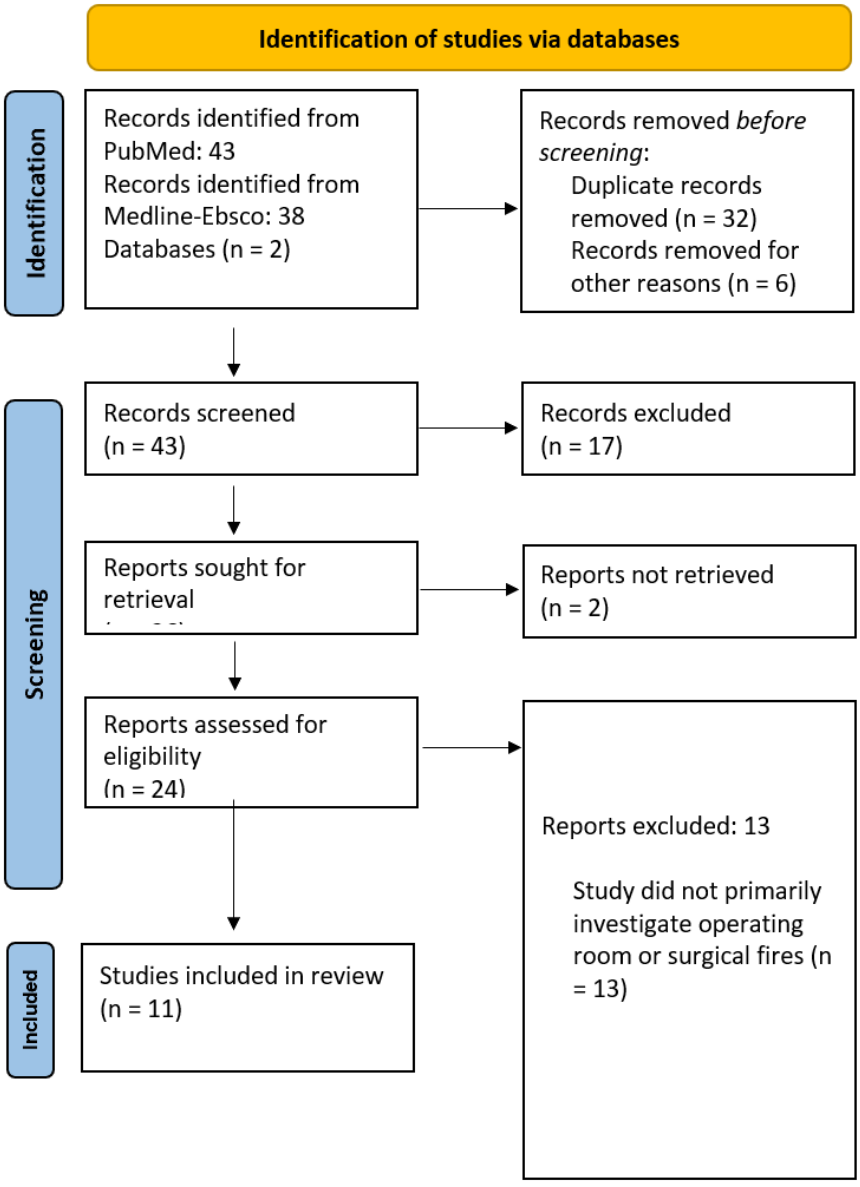
15-Aug-22	Start		October 24, 2022-November 14, 2022	Theoretical Framework		January 27-February 9, 2023	IRB Submission
	OR Fire Management and Prevention Deficit Identified		October 24, 2022-November 14, 2022	Project Aims and Objectives		February 21-28, 2023	Data Collection
August 15-20, 2022	Target Population Identified		October 24, 2022-November 14, 2022	GANTT Chart		April 15-30, 2023	Data Analysis
29-Aug-22	DNP Project Chair Confirmed		October 24, 2022-November 14, 2022	SWOT Analysis		June 20-27, 2023	Complete Academic Paper Draft
3-Oct-22	DNP Project Approved by Chair and Program Director		November 11, 2022-December 05, 2022	Literature Review		June 27-31, 2023	Complete Executive Summary
October 3-24, 2022	Introduction /Background		November 11, 2022-December 05, 2022	Project Design/Methods		10-Apr-24	Poster Presentation
October 3-24, 2022	Problem Statement		November 11, 2022-December 05, 2022	Evaluation Plan		April 10-17, 2024	Final Project Report
October 3-24, 2022	Needs Assessment		November 11, 2022-December 05, 2022	Revise Project Proposal			

Appendix C

Strengths	Weaknesses
· Electronic education accessibility · Program director reiterates project importance to first year SRNAs · University anesthesia principals professor to assist with the questionnaire	· Small sample population size · Limited response of participants who receive no rewards for participation
Opportunities	**Threats**
· Increased knowledge and confidence · Improved patient outcomes related to increased knowledge and confidence · Curriculum change	· Willingness of students to participate in the E-learning course · Miss keyed anonymous ID numbers between pre and post-tests

Appendix D

PRISMA 2020 Flow Diagram



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

Appendix E

Citation	Research Design & Level of Evidence	Population / Sample size n=x	Major Variables	Instruments / Data collection	Results
Apfelbaum, J. L., Caplan, R. A., Barker, S. J., Connis, R. T., Cowles, C., Ehrenwerth, J., Nickinovich, D. G., Pritchard, D., Roberson, D. W., Caplan, R. A., Barker, S. J., Connis, R. T., Cowles, C., de Richemond, A. L., Ehrenwerth, J., Nickinovich, D. G., Pritchard, D., Roberson, D. W., & Wolf, G. L. (2013). Practice advisory for the prevention and management of operating room fires: an updated report by the American Society of Anesthesiologists Task Force on Operating Room Fires. *Anesthesiology*, *118*(2), 271–290. https://doi.org/10.1097/ALN.0b013e31827773d2	Expert Opinion Level-VII	38	NA	ASA Member Survey	Practice advisory was created to identify situations conducive to fire, prevent OR fire occurrences, reduce adverse outcomes, and identify the key elements of a fire response protocol.
Chavis, S., Wagner, V., Becker, M., Bowerman, M. I., & Jamias, M. S. (2016). Clearing the Air About Surgical Smoke: An Education Program. *AORN Journal*, *103*(3), 289–296. https://doi.org/10.1016/j.aorn.2016.01.007	Expert Opinion Level-VII	OR personnel 82.9% participation	NA	Pre-education and post-education tool	A three-part e-learning module was developed. A 14.6% increase in the usage

					of smoke management systems resulted from training.
Cho, O.-H., Lee, D., & Hwang, K.-H. (2022). Patient safety awareness, knowledge and attitude about fire risk assessment during time-out among perioperative nurses in Korea. *Nursing Open*, *9*(2), 1353–1361. https://doi.org/10.1002/nop2.1180	Cross-Sectional Level-IV	158	Independent- risk-knowledge Dependent-risk-attitude	Hospital survey on patient safety culture survey tool	Knowledge had a significant effect on risk attitude (p=0.003
Coletto, K., Tariman, J. D., Lee, Y.-M., & Kapanke, K. (2018). Perceived Knowledge and Attitudes of Certified Registered Nurse Anesthetists and Student Registered Nurse Anesthetists on Fire Risk Assessment During Time-out in the Operating Room. *AANA Journal*, *86*(2), 99–108.	Cross-Sectional Level-IV	139	Attitudes, Knowledge, Years of experience, Education level, Age, Gender	Fire risk assessment tool Fire risk knowledge tool	There was no significance found between the mean scores of perceived knowledge and age, gender, years of experience, and education level
Culp, W. & Muse, K. (2021). Preventing Operating Room Fires: Impact of Surgical Drapes on Oxygen Contamination of the Operative Field. Journal of Patient Safety, 17 (8), e1846-	Experimental Level-III	30	Cotton or towel, utility, procedural, and steri-drape	Cardinal Health Guardian Three Liter Suction Canister)	oxygen permeability varied significantly between drapes tested. The

e1850. doi: 10.1097/PTS.0000000000000665.					surgical site oxygen concentration ranged from 20% to 58% (*P* = 0.0001).
Davis, L. B., Saxen, M. A., Jones, J. E., McGlothlin, J. D., Yepes, J. F., & Sanders, B. J. (2018). The Effects of Different Levels of Ambient Oxygen in an Oxygen-Enriched Surgical Environment and Production of Surgical Fires. *Anesthesia Progress*, *65*(1), 3–8. https://doi.org/10.2344/anpr-64-04-12 .	Experimental Level-III	16	Temperature. Humidity, oxygen flow rate	Fire event data collection	The number of combustion events with 60% oxygen was significantly lower than with both 80% (p= .0168) and 100% (p= .002)
Fisher, M. (2015). Prevention of Surgical Fires: A Certification Course for Healthcare Providers. *AANA Journal*, *83*(4), 271–274.	Prospective Cohort Study and survey Level-II	10	CRNAs Anesthesiologists	50-question knowledge assessment tool	Paired t-test revealed a significance in increased knowledge (p=0.001
Flowers J. (2004). Code red in the OR -- implementing an OR fire drill. AORN Journal, 79(4), 797–805. https://doi.org/10.1016/S0001-2092(06)60820-X	Simulation Study Level-III	7	Six fire drill scenarios were developed	Debriefing questionnaire	Staff reported an increase in confidence for handling OR fires in the future

Samuels, J. M., Carmichael, H., Wikiel, K. J., Robinson, T. N., Barnett, C. C., Jones, T. S., Jones, E. L., & Barnett, C. C., Jr. (2020). Carbon dioxide can eliminate operating room fires from alcohol-based surgical skin preps. *Surgical Endoscopy*, *34*(4), 1863–1867. https://doi.org/10.1007/s00464-019-06939-z	Experimental Level-III	NA	CO2 flow rate	CO2 insufflator and smoke evacuation pencil	Carbon dioxide eliminated fire formation at a flow rate of 1 L/min with CHG-IPA skin prep (0% vs. 60% with no CO2, $p < 0.0001$). Carbon dioxide reduced fire formation at 1 L/min (25% vs. 47% with no CO2, $p = 0.1$) with Iodine-IPA skin prep and fires were eliminated at 2 L/min of flow with Iodine-IPA skin prep ($p < 0.0001$).
Tola, D. H., Jillson, I. A., & Graling, P. (2018). Surgical Fire Safety: An Ambulatory Surgical Center Quality Improvement Project. *AORN Journal*, *107*(3), 335–344.	Quasi-Experimental Level-III	16	NA	27 question knowledge assessment tool	positive practice changes in participants according to surveys.

https://doi.org/10.1002/aorn.12081					Gains in knowledge from the education program were nonsignificant.
Truong, H., Qi, D., Ryason, A., Sullivan, A. M., Cudmore, J., Alfred, S., Jones, S. B., Parra, J. M., De, S., & Jones, D. B. (2022). Does your team know how to respond safely to an operating room fire? Outcomes of a virtual reality, AI-enhanced simulation training. *Surgical Endoscopy*, *36*(5), 3059–3067. https://doi.org/10.1007/s00464-021-08602-y	Quasi-Experimental Level-III	170	Surgical team members	Survey, simulation, and Pre-education and post-education tool	170 (94.4%) completed surveys. Participants included surgeons (17.2%), anesthesiologists (10.0%), allied health professionals (41.7%), and medical trainees (31.1%).

Appendix F

Operating Room Fire Prevention and Management

1. Please list the last 4 digits of your student ID number ____

2. Have you had prior OR fire prevention and management training? (Only on the pre-test)

    a. Yes
    b. No

3. Which of the following is not a component of the fire triad?
    a. Fuel
    b. Combustor
    c. Ignition source
    d. Oxidizer
4. All of the following are potential ignition sources except?
    a. Desiccated soda lime
    b. Fiberoptic lights
    c. Sevoflurane at less than 2 L/min fresh gas flow
    d. 3-lead ECG monitor
5. True or False: Lasers do not require direct contact with a fuel source for fire to occur
    a. True
    b. False
6. Which of the following are correct statements on surgical fire prevention (select 2).
    a. Limit O2 concentration to less than 40% FiO2 when possible
    b. Have sterile irrigation fluid ready on the anesthesia machine
    c. Coat facial hair with a water-soluble lubricant during head and neck surgeries
    d. Administer O2 through a facemask versus a nasal cannula whenever possible
7. Which of the following statements are true (select 2).
    a. Only 50% of states are required to report OR fires
    b. Lasers are responsible for the majority of OR fires
    c. Head and face are the most common site of OR fires
    d. Draping can occur while the alcohol-based solution is wet as long as the incision is not made until the solution has dried.
    e. Bowel gas is a fuel that should be considered during intraabdominal laser procedures
8. True or False: Volatile anesthetics are nonflammable?
    a. True
    b. False
9. Which of the following statements are correct? (Select 2)
    a. CO2 should be flushed over the site of the laser to separate the oxidizer from the source of ignition during airway and facial procedures
    b. Helium is more resistant to ignition than oxygen due to its high thermal conductivity

c. The presence of blood on a PVC endotracheal tube makes it susceptible to damage from the Nd: YAG laser
d. The addition of methylene blue to the ETT cuff alerts the anesthetist of cuff rupture

10. Which of the following is the first action taken by the anesthetist after a recognized airway fire?

a. Pour saline into the airway
b. Remove ETT or LMA
c. Turn off gas flows
d. Alert the surgical team and sound the fire alarm

11. Which of the following is the most appropriate to extinguish an OR fire

a. Class A-rated extinguisher
b. Class B-rated extinguisher
c. Class AC-rated extinguisher
d. Class D-rated extinguisher

12. Which of the following is not a part of the American Society of Anesthesiologists Operating Room Fires Algorithm?

a. Allow sufficient drying time for flammable skin-prepping solutions
b. Avoid using ignition sources in proximity to an oxidizer-enriched atmosphere
c. Moisten sponges and gauze when used in proximity to ignition sources
d. Place an ETT or LMA for all high-risk cases requiring greater than 30% FiO2

13. Rate your confidence in the prevention and management of OR fires heading into clinical

a. Extremely confident
b. Moderately confident
c. Confident
d. Slightly unconfident
e. Extremely unconfident

Appendix G

Operating Room Fire Prevention and Management

1. Please list the last 4 digits of your student ID number ____

2. Have you had prior OR fire prevention and management training? (Only on the pre-test)

    a. Yes
    b. No

3. Which of the following is not a component of the fire triad?
    a. Fuel
    b. Combustor
    c. Ignition source
    d. Oxidizer
4. All of the following are potential ignition sources except?
    a. Desiccated soda lime
    b. Fiberoptic lights
    c. Sevoflurane at less than 2 L/min fresh gas flow
    d. 3-lead ECG monitor
5. True or False: Lasers do not require direct contact with a fuel source for fire to occur
    a. True
    b. False
6. Which of the following are correct statements on surgical fire prevention (select 2).
    a. Limit O2 concentration to less than 40% FiO2 when possible
    b. Have sterile irrigation fluid ready on the anesthesia machine
    c. Coat facial hair with a water-soluble lubricant during head and neck surgeries
    d. Administer O2 through a facemask versus a nasal cannula whenever possible
7. Which of the following statements are true (select 2).
    a. Only 50% of states are required to report OR fires
    b. Lasers are responsible for the majority of OR fires
    c. Head and face are the most common site of OR fires
    d. Draping can occur while the alcohol-based solution is wet as long as the incision is not made until the solution has dried.
    e. Bowel gas is a fuel that should be considered during intraabdominal laser procedures
8. True or False: Volatile anesthetics are nonflammable?
    a. True
    b. False
9. Which of the following statements are correct? (Select 2)

a. CO_2 should be flushed over the site of the laser to separate the oxidizer from the source of ignition during airway and facial procedures
b. Helium is more resistant to ignition than oxygen due to its high thermal conductivity
c. The presence of blood on a PVC endotracheal tube makes it susceptible to damage from the Nd: YAG laser
d. The addition of methylene blue to the ETT cuff alerts the anesthetist of cuff rupture

10. Which of the following is the first action taken by the anesthetist after a recognized airway fire?
a. Pour saline into the airway
b. Remove ETT or LMA
c. Turn off gas flows
d. Alert the surgical team and sound the fire alarm

11. Which of the following is the most appropriate to extinguish an OR fire
a. Class A-rated extinguisher
b. Class B-rated extinguisher
c. Class AC-rated extinguisher
d. Class D-rated extinguisher

12. Which of the following is not a part of the American Society of Anesthesiologists Operating Room Fires Algorithm?
a. Allow sufficient drying time for flammable skin-prepping solutions
b. Avoid using ignition sources in proximity to an oxidizer-enriched atmosphere
c. Moisten sponges and gauze when used in proximity to ignition sources
d. Place an ETT or LMA for all high-risk cases requiring greater than 30% FiO_2

13. Rate your confidence in the prevention and management of OR fires heading into clinical

a. Extremely confident
b. Moderately confident
c. Confident
d. Slightly unconfident
e. Extremely unconfident

14. I had an opportunity to learn how to apply course concepts to future real-life experiences.

1= strongly disagree with the statement
2= disagree with the statement
3= undecided (neither agree or disagree)
4= agree with the statement
5= strongly agree with the statement
NA= does not apply to learning encounter

15. Using learning experience activities made my learning more productive.

1= strongly disagree with the statement
2= disagree with the statement

3= undecided (neither agree or disagree)
4= agree with the statement
5= strongly agree with the statement
NA= does not apply to learning encounter

16. I could complete the coursework in a reasonable amount of time.

1= strongly disagree with the statement
2= disagree with the statement
3= undecided (neither agree or disagree)
4= agree with the statement
5= strongly agree with the statement
NA= does not apply to learning encounter

17. The objectives for the learning experience were clear and easy to understand

1= strongly disagree with the statement
2= disagree with the statement
3= undecided (neither agree or disagree)
4= agree with the statement
5= strongly agree with the statement
NA= does not apply to learning encounter

18. The learning experience offered a variety of ways in which to learn the material.

1= strongly disagree with the statement
2= disagree with the statement
3= undecided (neither agree or disagree)
4= agree with the statement
5= strongly agree with the statement
NA= does not apply to learning encounter

Appendix H

Educational Practices Questionnaire-C (Across the Curriculum)

Directions for participants completing the EPQ-C: In order to measure if the best practices are being used in your most recent learning encounter, please complete the survey below as you perceive it. For Part 1, you will rate your perceived agreement or disagreement with the item, and for Part 2, you will rate the perceived importance of the item. There are no right or wrong answers, only your perceived amount of agreement or importance. Please use the scoring system below under Part 1 and Part 2 to answer the questions. Circle your response for Part 1 and Part 2 for each item.

Items to Rate	Part 1 Use the following scoring system when rating the educational practices for your perceived agreement or disagreement of each item: 1 = strongly disagree with the statement 2 = disagree with the statement 3 = undecided (neither agree or disagree) 4 = agree with the statement 5 = strongly agree with the statement N/A = does not apply to this learning encounter	Part 2 Use the following scoring system to rate the educational practices for your perceived agreement of importance of each item: 1 = not important 2 = somewhat important 3 = neutral 4 = important 5 = very important N/A = does not apply to this learning encounter
Student-Faculty Interaction		
1. My instructor responded to my needs during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
2. I was able to gain a deeper understanding of the material based on insights and examples from the instructor that I could adapt to my own practice	1 2 3 4 5 N/A	1 2 3 4 5 N/A
3. I learned from the comments made by the instructor before, during, or after the learning.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
4. I had the chance to discuss the learning experience objectives with my teacher.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
Collaborative Learning		
5. I had the chance to collaborate with my peers during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
6. I had the opportunity to discuss the ideas and concepts with other students during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
7. I had the opportunity to discuss my thoughts with my peers during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A

 June 3, 2021

Educational Practices Questionnaire-C (Across the Curriculum)

Active learning		
8. I had the opportunity to reflect on my thinking during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
9. I had the opportunity to reflect upon any emotions I experienced during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
10. I had an opportunity to learn how to apply course concepts to future real-life experiences	1 2 3 4 5 N/A	1 2 3 4 5 N/A
11. The learning experience activities made my learning time more productive.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
Feedback		
12. I received feedback from the instructor about my thinking during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
13. I had the opportunity to give and receive feedback from my peers during the learning experience.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
Time on Task		
14. Using learning experience activities made my learning more productive.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
15. I could complete the coursework in a reasonable amount of time.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
16. In the given timeframe for the learning experience, there were enough moments to incorporate the material in ways that helped me apply it to my learning.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
High Expectations		
17. The instructor provided an environment for learning that encouraged me to challenge my own thinking and abilities.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
18. The objectives for the learning experience were clear and easy to understand.	1 2 3 4 5 N/A	1 2 3 4 5 N/A

 June 3, 2021

Educational Practices Questionnaire-C (Across the Curriculum)

Diverse Learning	Comments	
19. The instructor individualized the learning experience to meet my particular needs.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
20. My instructor was inclusive of different perspectives in thinking and learning.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
21. The learning experience offered a variety of ways in which to learn the material.	1 2 3 4 5 N/A	1 2 3 4 5 N/A
22. The learning experience offered a variety of ways of assessing my learning.	1 2 3 4 5 N/A	1 2 3 4 5 N/A

Appendix I

Items to Rate	Use the following scoring system when rating the educational practices for your perceived agreement or disagreement of each item: 1= strongly disagree with the statement 2= disagree with the statement 3= undecided (neither agree or disagree) 4= agree with the statement 5= strongly agree with the statement NA= does not apply to learning encounter
10. I had an opportunity to learn how to apply course concepts to future real-life experiences	**1 2 3 4 5 NA**
14. Using learning experience activities made my learning more productive	**1 2 3 4 5 NA**
15. I could complete the coursework in a reasonable amount of time	**1 2 3 4 5 NA**
18. The objectives for the learning experience were clear and easy to understand	**1 2 3 4 5 NA**
21. The learning experience offered a variety of ways in which to learn the material	**1 2 3 4 5 NA**