Archives of Anesthesiology and Critical Care (In Press); x(x): xx-xx.

Available online at http://aacc.tums.ac.ir

Research Article

Using Micro-Learning to Enhance Knowledge and Skills of Airway Management in Nurse Anesthesia Students: An Interventional Study

Masoumeh Albooghobeish[1], Alireza Ghalandeh[1]*, Ali Khalafi[1], Mohammad Hosein Haghighizadeh[2]

[1]*Department of Anesthesology, School of Allied Medical Sciences, Ahvaz Jundishapur Univercity of Medical Sciences, Ahvaz, Iran.*

[2]*Department of Biostatistics, School of Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.*

ARTICLE INFO

Article history:
Received 27 April 2024
Revised 17 May 2024
Accepted 02 June 2024

Keywords:
Micro-learning;
E-learning;
Airway management;
Nurse anesthesia;
Skill;
Knowledge;
Iran

ABSTRACT

Background: As a subfield of E-Learning, Micro-Learning provides asynchronous instruction to reduce mental strain and boost understanding by delivering educational content in bite-sized, concise learning modules. This study aimed to investigate the effect of Micro-Learning on the airway management knowledge and skills of nurse anesthesia students.

Methods: This Non-Randomized Controlled study, employing a Pre-test-Post-test design, included 52 nurse anesthesia students in Iran. Participants were first assessed with a Pre-test, and then assigned to either the M-L M (n=26) or T M (n=26) groups. Over three weeks, the M-L M group received Micro-Learning-based materials through social media, while the T M group received traditional face-to-face instruction. The intervention focused on airway management during peri-induction of general anesthesia. Then, the first and second Post-tests were given to assess the acquisition and retention of knowledge and skills, using a researcher-made instrument called AMAI-NA.

Results: Based on within-group comparisons, in both M-L M and T M groups mean scores of both Knowledge and Skills significantly increased from the Pre-test to 1st Post-test, then declined from 1st Post-test to 2nd Post-test. Yet, 2nd Post-test mean scores remained significantly higher than the Pre-test for both groups. Based on Inter-group comparisons, despite the absence of a statistically significant difference in Pre-test mean scores between the two groups, the mean scores for Knowledge and Skills of the M-L M group were significantly higher than those of the T M group in 1st and 2nd Post-tests. Furthermore, the M-L M group exhibited a greater increase in mean scores from the Pre-test to 1st and 2nd Post-tests compared to the T M group, as well as a lesser decrease from 1st Post-test to 2nd Post-test.

Conclusion: This study demonstrated that Micro-Learning significantly enhanced the acquisition and retention of knowledge and skills related to airway management, compared to the traditional method.

The authors declare no conflicts of interest.

*Corresponding author.
E-mail address: alirezaghal79@gmail.com

Introduction

Safe and effective airway management during peri-induction of general anesthesia is a critical responsibility shared by all anesthesia team members [1]. This multifaceted task requires meticulous preoperative assessment of the patient's airway anatomy, meticulous preoxygenation, skillful placement of an artificial airway device, and continuous monitoring for potential airway complications throughout the process [2]. Successful airway management is a cornerstone of safe anesthesia practice [3]. The anesthesia team, consisting of anesthesiologists and nurse anesthetists, must possess high flexibility and skills to manage both routine and challenging airway management scenarios [4]. They should have a thorough understanding of airway anatomy and physiology, as well as complete mastery of airway management equipment and techniques. Furthermore, they must be able to respond quickly and effectively to potential complications [5-6].

As far as airway management education is concerned, the inherent complexity and multi-stage nature of the subject matter can present significant challenges for both the instructors and the students. This is particularly evident in traditional pedagogical approaches, which often rely heavily on lecture-based instruction [7]. The limitations of such methods have led many experts to advocate for a diversification of teaching methodologies [8]. Research findings indicate that despite the fact that over 70% of clinical instructors utilize traditional teaching methods, 90% of the students prefer modern teaching approaches [9]. This preference stems from the belief that innovative and contemporary approaches can lead to a deeper understanding of the material, acquisition of more skills, and ultimately, enhancement of student performance [10]. This underscores the importance of adopting suitable and modern teaching methods to improve the learning experience of nurse anesthesia students.

In today's rapidly changing world, effective learning is not possible without embracing innovative educational methods [11]. The limitations inherent in traditional educational methods, coupled with the concurrent growth of information technology and ubiquitous electronic devices, have fostered the emergence of “electronic learning (E-Learning)” as a valuable complement or alternative in educational courses [12-13]. E-Learning encompasses the utilization of modern technologies – computers, mobile phones, the Internet, multimedia discs, and electronic journals – to facilitate knowledge acquisition and skill development [14]. This approach offers many advantages, including increased flexibility in learning pace and schedule, cost-effectiveness, and enhanced learning outcomes [15-16]. In its various forms, E-Learning has been demonstrably successful in improving the knowledge base of learners across diverse healthcare fields [17].

Emerging as a subbranch of E-Learning, Micro-Learning presents an innovative instructional approach. It delivers educational content in a step-by-step manner through concise learning modules and short-term activities. This approach aims to reduce the cognitive burden associated with complex material, thereby facilitating learner comprehension [18-19]. Characterized by the delivery of learning modules with a maximum duration of 15 minutes, Micro-Learning encompasses a variety of educational formats, including brief written text, short graphics, Micro-Podcasts, Micro-Videos, and Micro-Quizzes [9, 11, 20]. Each of these focused learning units targets a specific and well-defined objective. This targeted approach can potentially contribute to enhanced learner comprehension and superior knowledge retention [9, 17]. Micro-Learning is an asynchronous approach that delivers learning content primarily through mobile devices and personal computers. This empowers learners to have control over the time, place, and manner in which they access educational materials, enabling them to shape their learning process actively [21-22]. This makes Micro-Learning ideal for accommodating learners with diverse learning styles [23].

While the integration of Micro-Learning in nursing and medical educational programs remains a nascent area of exploration, initial research suggests its potential to enhance the teaching-learning experience. This, in turn, could contribute to advancements in healthcare service quality through cultivation of a more proficient healthcare workforce [9, 11, 23]. It is noteworthy that prior research has primarily concentrated on the influence of the Micro-Learning method on the lower levels of Bloom's taxonomy and Kirkpatrick's model. This underscores the necessity for further investigation into its effectiveness in fostering the acquisition of practical skills, extending beyond the mere accumulation of knowledge. Furthermore, the existing body of research presents an ambiguous picture regarding the impact of Micro-Learning on learner retention. This inconclusive outcome necessitates additional exploration to determine its efficacy in this domain definitively. Finally, it is crucial to acknowledge that past studies have predominantly employed interventions of limited complexity, thus failing to fully exploit the potential inherent within the Micro-Learning approach. This very limitation presents a compelling opportunity for novel research endeavors that incorporate more substantial interventions.

Motivated by the aforementioned gaps and the lack of similar research, this study specifically investigates whether Micro-Learning, compared to traditional face-to-face lecture-based education, can improve nurse anesthesia students’ acquisition and retention of airway

management knowledge and skills during peri-induction of general anesthesia.

Methods

Design and setting

This Non-Randomized Controlled Study with a Pre-test-Post-test design was conducted in Iran from November 2023 to January 2024. it was conducted on nurse anesthesia students at Ahvaz Jundishapur University of Medical Sciences and had a control group.

Sampling

Eligible students were recruited using a convenience sampling method (n=52). Inclusion criteria for the study were willingness to participate, informed consent, and active participation in the operating room anesthesia internship according to the official curriculum. The exclusion criterion was the student's unwillingness to continue cooperation at any stage of the study.

Allocation

To neutralize the effect of the intervening variable on the results of the study, the samples were first blocked based on the General Point Average (GPA) variable and then divided into the intervention (n=26) and control (n=26) groups using a Random Number Table.

Instruments

Data collection for this study utilized a researcher-made instrument termed AMAI-NA (Airway Management Assessment Instrument for Nurse Anesthetists). The AMAI-NA was constructed by drawing upon items from international anesthesia resources, validated academic articles, and expert opinions from faculty members of the nurse anesthesia department. This instrument comprised three distinct sections:

I. Demographic information: Included variables age, gender, and GPA.

II. Questionnaire (to assess the student's theoretical knowledge): This questionnaire consisted of 30 standard four-option questions. The Content Validity Index (CVI) of the questionnaire was calculated after being presented to 10 faculty members of the nurse anesthesia department which was 0.88. Its reliability was also analyzed by measuring Cronbach's alpha coefficient which was 0.72.

III. Checklist (to assess the student's skills): This checklist was developed based on the Likert scale and had three subscales:

a. Pre-induction phase (6 items)
b. Intra-induction phase (4 items)
c. Post-induction phase (6 items)

The CVI was also calculated alongside the questionnaire which was 0.83. Its reliability was also analyzed by measuring Cronbach's alpha coefficient which was 0.79.

Procedure

After obtaining approval from the Research Ethics Committees of Ahvaz Jundishapur University of Medical Sciences, eligible students were invited to an introductory session in the faculty. During this session, a comprehensive overview was provided encompassing the following points: study guides, detailed research goals, and potential benefits of participation. Then, the students provided their informed consent for participation. Next, to assess the students' initial knowledge and skills level, all participated in a Pre-test held in the faculty's practice room. Subsequently, they were first blocked by GPA, and then randomly assigned to either the M-L M (intervention) or T M (control) groups using a random number table and the students' unique ID numbers.

Over a three-week course, pre-determined educational materials were delivered to the students within the M-L M and T M groups via distinct educational methodologies:

T M Group: The participants of this group participated in three three-hour face-to-face workshop sessions, held on Saturdays for three consecutive weeks. These workshops focused on the practical and theoretical aspects of airway management in the peri-induction of general anesthesia. Each week was dedicated to a separate phase: airway management during pre-induction, intra-induction, and post-induction of general anesthesia. During the course, a traditional lecture-based approach was used to deliver educational content (PowerPoint slides) to the students. To complement the theoretical content, at the end of each week (on Wednesdays), a session was held by the research team in the faculty's practice room, providing an opportunity to practice what students have learned by low-fidelity simulation.

M-L M Group: Over the course of three consecutive weeks, the members of this group participated in a dynamic educational program that included the following diverse educational materials:

- Micro-Videos: Eighteen video modules, each with a maximum running time of 15 minutes, incorporating a combination of slides, images, video clips, and conceptual maps.
- Micro-Podcasts: Three 15-minute audio podcasts to create alternative learning paths and reinforce listening comprehension of the material.
- Micro-Quizzes: Fifteen short quizzes, each consisting of five four-option questions with limited time, to encourage self-assessment and active participation.
- Micro-Games: Three brief games consisting of short multiple-choice questions, to increase engagement.

To strengthen the self-regulation aspect of learning and create opportunities for continuous learning at any time and place, a private channel and a private group were created on the Telegram messenger at the beginning of the course. This channel and group, using the potential of Web 2.0, provided a platform for interaction and

knowledge exchange between students and the research team. First, the expectations and details of the intervention were explained to the students on this platform, and then, Micro-Contents (Micro-Learning-based Contents) were provided to them through the channel. To mitigate potential bias, they were instructed to refrain from sharing the educational content they received with members of the T M group. The research team maintained an active presence within the online platform, fostering a collaborative environment. This included addressing participant inquiries, clarifying any ambiguities in the materials, and facilitating peer-to-peer interaction.

Timeline of Educational Activities of the Course in M-L M group (Figure 1):

First Week: The first week of the course began with a focus on the "pre-induction of general anesthesia" phase.

a. Over a five-day period commencing on Saturday and concluding on Wednesday, five Micro-Videos, each no longer than 10 minutes, were presented. The topics included “preparation of airway management equipment”, “preparation and testing of anesthesia machines”, “an overview of general anesthetic drugs”, “patient airway assessment”, and “patient positioning”. At a 6-hour interval following the release of each Micro-Video, a five-question Micro-Quiz was administered with a limited time frame to assess learning and enhance student participation.
b. On Wednesday, the research team conducted a hands-on skills training session utilizing low-fidelity simulation in the faculty’s practice room to complement theoretical instruction by practicing what students have learned.
c. On Thursday, to summarize key concepts, consolidate learning, and enhance learning retention, the content presented in the previous days was presented in two summarized and concise formats: a Micro-Video and a Micro-Podcast. Each multimedia piece adhered to a 15-minute maximum runtime and utilized concept maps, videos, visuals, and audio narration to communicate the essential takeaways effectively.
d. On Friday, students participated in a researcher-developed Micro-Game, titled "Anesthopardy!”. Inspired by the television program Jeopardy!, the game challenged participants to use their knowledge to guess the correct question out of four options, based on an answer provided by a host. Points were awarded for each correct answer. The game was facilitated through a video chat hosted on the Telegram platform.

To ensure standard educational materials (as seen in Figure 2), the research team followed electronic learning content guidelines [24-26].

Second Week: In the second week of the course, the focus shifted to the "Intra-induction of general anesthesia" Phase. The structure of educational content delivery and practical exercises mirrored those of the first week, which included “pre-oxygenation”, “airway management techniques”, “supraglottic airway device placement”, “laryngoscopy”, and “endotracheal intubation”. This content was presented in a Micro-Learning format, utilizing Micro-Videos, Micro-Quizzes, Micro-Podcasts, and Micro-Games, consistent with the approach employed in the first week. Practical training sessions were conducted in the faculty's practice room, facilitated by the research team, and utilized low-fidelity simulation.

Third Week: The last week of the course focused on the “post-induction of general anesthesia” phase. The educational content format, presentation schedule, and practical activities followed a similar pattern to previous weeks. The educational content covered “ensuring proper endotracheal tube (ETT) placement”, “ETT fixation”, “securing connections”, “ventilator setups”, and “airway protection for patients after general anesthesia induction”.

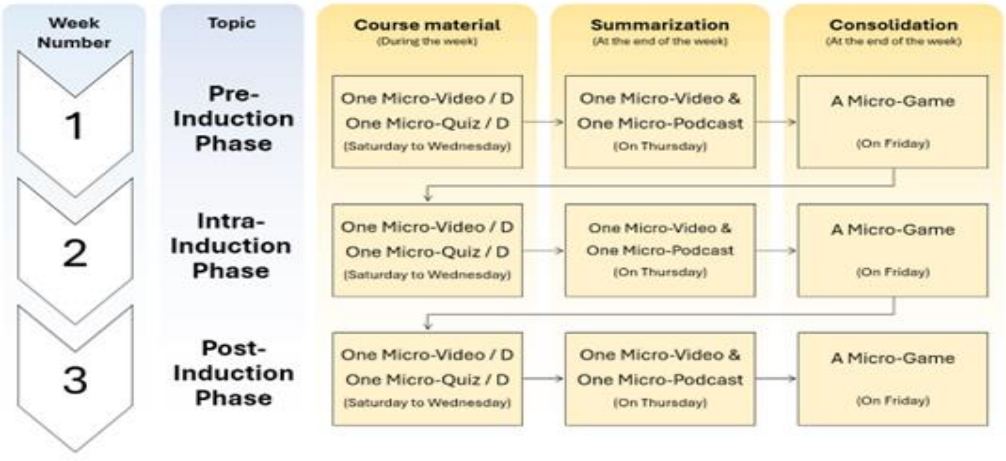

Figure 1- Timeline and The Order of Micro-Learning-Based Interventions Implemented in the M-L M Group By Time

Figure 2- An example of the produced content including concept maps and visuals

After the completion of the three-week course, the 1st and 2nd Post-tests were administered in the same manner as the Pre-test, and the data were collected.

- First Post-test: Ten days after the end of the educational interventions, the 1st Post-test was conducted to assess the level of knowledge and skills acquired by the students in both the M-L M and T M groups.
- Second Post-test: To assess the long-term retention of students' knowledge and skills, the 2nd Post-test was conducted one month after the 1st Post-test.

Statistical Analysis

To investigate the homogeneity of intervention and control groups in terms of age, GPA, and gender, statistical tests were employed based on the type of variable and the distribution of the data. Specifically, the Mann-Whitney U test, Independent-Samples T Test, and Chi-Square Test were utilized, for age, GPA, and gender respectively. The Shapiro-Wilk test and an examination of the shape of the samples' distributions were used to assess the data distribution. The mean scores of each group at each time point were then calculated. In the following, for normally distributed data, parametric tests (included Independent-Samples T Test for inter-group comparisons and Repeated Measures ANOVA for investigating within-group changes) were employed, while for non-normally distributed data, non-parametric tests (included Mann-Whitney U for inter-group comparisons and Friedman Test for investigating within-group changes) were utilized. All statistical analyses were conducted using IBM SPSS Statistics version 27 software.

Results

The present study was conducted with the participation of 52 nurse anesthesia students of whom 26 were in the M-L M group and the other 26 were in the T M group. The two groups were homogeneous in terms of gender, age, and GPA and there was no significant difference between them (P=1, P=0.161, and P=0.627) (Table 1). According to the results of the Z-Score analysis, no outlier data was identified.

Within-Group Comparison

M-L M Group:

Knowledge: The mean scores exhibited a significant increase of 145.73% from the Pre-test to the 1st Post-test, followed by a decrease of 21.39% from the 1st Post-test to the 2nd Post-test. Nevertheless, the mean scores in the 2nd Post-test remained 93.16% higher compared to the Pre-test. All these changes were statistically significant (P<0.001, P<0.001, and P<0.001) (Table 2,3).

Skills: The mean score of Skills (Overall) also changed over the three testing stages, similar to the knowledge mean scores. The mean scores increased by 104.40% from the Pre-test to the 1st Post-test and decreased by 23.45% from the 1st Post-test to the 2nd Post-test. However, the 2nd Post-test scores were still 56.47% higher than the Pre-test scores. All these changes were statistically significant (P<0.001, P<0.001, and P<0.001) (Table 2, 3).

The changes in mean scores of pre-induction, intra-induction, and post-induction phases were consistent with the changes in the mean scores of Skills (Overall). The mean scores of pre-induction, intra-induction, and post-induction phases, increased by 104.41%, 87.24%, and 117.31%, respectively, from the Pre-test to the 1st Post-test. Then, from the 1st Post-test to the 2nd Post-test, the mean scores decreased by 18.25%, 24.86%, and 20.02%, respectively. The mean scores in the 2nd Post-test were 67.10%, 40.68%, and 73.78% higher than that in the Pre-test, respectively. All changes in mean scores were statistically significant for all three Phases (Table 2, 3).

T M Group:

Knowledge: The mean score increased by 81.95% from the Pre-test to the 1st Post-test, and decreased by 25.79% from the 1st Post-test to the 2nd Post-test. However, the mean score in the 2nd Post-test was 35.02% higher than that in the Pre-test. All these changes were statistically significant (P<0.001, P<0.001, and P<0.001) (Table 2, 3).

Skills: There was a substantial increase of 72.12% in the mean score of Skill (Overall) from the Pre-test to the 1st Post-test. However, this was followed by a decrease of 28.92% from the 1st Post-test to the 2nd Post-test. Consequently, the mean score in the 2nd Post-test remained 22.20% higher than that in the Pre-test. All these changes were statistically significant (P<0.001, P<0.001, and P<0.001) (Table 2, 3).

The alterations observed in the mean scores of all three phases corresponded consistently with the fluctuations in the mean scores of skills (Overall). The mean scores of pre-induction, intra-induction, and post-induction phases, increased by 74.90%, 58.25%, and 79.96%, respectively, from the Pre-test to the 1st Post-test. Then, from the 1st Post-test to the 2nd Post-test, the mean scores decreased by 31.56%, 23.97%, and 26.33%, respectively. The mean scores in the 2nd Post-test were 19.69%, 20.38%, and 32.57% higher than that in the Pre-test, respectively. All changes in mean scores were statistically significant for all three Phases (Table 2, 3).

Inter-Group Comparison

Knowledge: Following the educational intervention, the mean score of the M-L M group in the 1st Post-test was significantly higher than that of the T M group (P=0.047), while there was no significant difference between the two groups' mean scores in the Pre-test (P=0.071). On the other hand, the extent of score decline from the 1st Post-test to the 2nd Post-test was lower in the M-L M group compared to the T M group, resulting in a significant difference in the scores of the 2nd Post-test between the two groups (P=0.016) (Table 4).

Skills: As with the Knowledge test, despite the lack of any significant difference between the mean scores of Skills (Overall) in the Pre-test (P=0.639), the mean score of the M-L M group in the 1st Post-test was significantly higher than that of the T M group (P<0.001). Conversely, the decrease in mean score from the 1st Post-test to the 2nd Post-test was lower in the M-L M group compared to the T M group, leading to a significant difference in the mean scores of the 2nd Post-test between the two groups (P<0.001) (Table 4).

Comparison of the mean scores of pre-induction, intra-induction, and post-induction phases revealed a pattern closely resembling the results of comparing Knowledge and skills (Overall) variables between groups, despite the lack of significant differences in the Pre-test (P=0.358, P=0.581, and P=0.497). The mean scores of the M-L M group in the 1st Post-test were significantly higher than those of the T M group due to a considerable increase in mean scores (P<0.001, P<0.001, and P<0.001). Furthermore, considering the much smaller decline in scores in the 2nd Post-test in the M-L M group compared to the T M group, the difference in mean scores between the two groups was statistically significant (P<0.001, P=0.006, and P<0.001) (Table 4).

Table 1- Comparison of Participants' Gender, Age, and GPA Between the Groups

Variable		M-L M (n=26)	T M (n=26)
Gender	Female (%)	18 (69.23)	18 (69.23)
	Male (%)	8 (30.76)	8 (30.76)
	P value*	1	
Age	Mean ± Std. Deviation	21.57 ± 2.98	23.38 ± 5.72
	P value**	0.161	
GPA	Mean ± Std. Deviation	16.51 ± 1.64	16.73 ± 1.67
	P value***	0.627	

* Chi-Square Test
** Mann-Whitney Test
*** Independent-Samples T Test

Table 2- Mean Scores of Two Groups by Time

Group	Variable	Mean ± Std. Deviation		
		Pre-test	1st Post-test	2nd Post-test
M-L M	Knowledge	08.92 ± 03.08	21.92 ± 05.64	17.23 ± 04.67
	Skills (Overall)	36.07 ± 10.10	73.73 ± 05.56	56.44 ± 05.54
	Pre-Induction	13.59 ± 04.45	27.78 ± 01.98	22.71 ± 02.50
	Intra-Induction	09.88 ± 02.95	18.50 ± 01.69	13.90 ± 01.80
	Post-Induction	12.59 ± 04.14	27.36 ± 03.69	21.88 ± 03.04
T M	Knowledge	10.42 ± 03.25	18.96 ± 04.96	14.07 ± 02.63
	Skills (Overall)	34.90 ± 07.73	60.07 ± 07.12	42.65 ± 06.79
	Pre-Induction	12.59 ± 03.74	22.02 ± 03.28	15.07 ± 03.73
	Intra-Induction	10.30 ± 02.52	16.30 ± 01.96	12.40 ± 02.19
	Post-Induction	11.88 ± 03.30	21.38 ± 03.29	15.75 ± 02.21

Table 3- Within-Group Comparison.

Group	Variable	P value*		
		Pre-test vs. 1st Post-test	Pre-test vs. 2nd Post-test	1st Post-test vs. 2nd Post-test
M-L M	Knowledge	<0.001	<0.001	<0.001
	Skills (Overall)	<0.001	<0.001	<0.001
	Pre-Induction	<0.001	<0.001	<0.001
	Intra-Induction	<0.001	<0.001	<0.001
	Post-Induction	<0.001	0.001	<0.001
T M	Knowledge	<0.001	<0.001	<0.001
	Skills (Overall)	<0.001	<0.001	<0.001
	Pre-Induction	<0.001	0.004	<0.001
	Intra-Induction	<0.001	<0.001	<0.001
	Post-Induction	<0.001	<0.001	<0.001

* Repeated Measures ANOVA/Freidman Test

Table 4- Inter-Group Comparison of Mean Scores at Each Time Point.

Variable	P value*		
	Pre-test	1st Post-test	2nd Post-test
Knowledge	0.071	0.047	0.016
Skills (Overall)	0.639	<0.001	<0.001
Pre-Induction	0.358	<0.001	<0.001
Intra-Induction	0.581	<0.001	0.006
Post-Induction	0.497	<0.001	<0.001

* Independent-Samples T Test/Mann Whitney U Test

Discussion

Key results

This study investigated the impact of Micro-Learning on enhancing nurse anesthesia students' knowledge and skills in airway management. The M-L M group showed a more significant improvement in knowledge and skills acquisition than did the T M group. Moreover, the retention of knowledge and skills in the M-L M group was higher than that of the T M group. Therefore, adoption of Micro-Learning significantly contributed to enhancing students' learning outcomes.

Interpretation

The findings of this study underscore the effectiveness of both traditional and Micro-Learning methodologies in improving student learning outcomes. While the traditional approach offers advantages such as multifaceted interaction with learning materials and a shared physical learning environment, particularly beneficial for students encountering new concepts or skills, Micro-Learning significantly enhances knowledge and skills acquisition within the Micro-Learning group. This advantage can be attributed to the inherent flexibility of Micro-Learning, which allows for personalized learning experiences and fosters a deeper understanding of complex concepts [21]. Moreover, Micro-Learning addresses limitations inherent in traditional methods by providing ubiquitous access to educational materials, enabling spaced repetition for knowledge consolidation, and promoting continuous reinforcement of learning [9].

The decline observed in both groups' knowledge and skills scores during the follow-up assessment may be attributed to forgetting and skill decay. However, the larger decline observed in the traditional method group suggests its susceptibility to these challenges. The passive nature of lecture-based instruction and the lack of repetition opportunities inherent in synchronous delivery both contribute to superficial understanding and lower retention [27]. Conversely, the smaller decline in the Micro-Learning group's scores indicates that Micro-Learning not only facilitates initial learning but also promotes knowledge and skills consolidation [17]. The delivery of information in bite-sized modules allows for easier review and repetition, which will lead to enhanced retention [21]. Additionally, Micro-Learning's use of multimedia material may lead to deeper cognitive engagement, potentially strengthening long-term memory and improving recall [8].

While this study highlights the potential advantages of Micro-Learning for specific learning outcomes compared to traditional lectures, it is essential to recognize the continued value of both methodologies in educational and training contexts. Careful consideration of learning objectives, target audience characteristics, and available resources should inform the selection of the optimal approach.

Comparison with previous studies

The present study aligns with a growing body of research supporting the efficacy of Micro-Learning in medical education. Our findings echo those of Ichiuji et al. (2022), who demonstrated superior knowledge gain and retention among medical students using Micro-Learning modules compared to traditional online learning formats [28]. Furthermore, our results resonate with Sözmen et al. (2021), who reported that Micro-Learning approaches fostered increased motivation and independent learning among medical students during the COVID-19 pandemic [23]. The present study also lends support to the study of Sedaghatkar et al. (2023) in which the synergistic combination of Micro-Learning with task-based learning strategies yielded significant improvements in medical students' knowledge and clinical performance [11]. Additionally, our findings regarding improved knowledge acquisition concur with those of Zarehshah et al. (2022) who investigated the impact of remote classes utilizing Micro-Learning content on nursing students' learning outcomes in clinical education [9]. Similarly, results of Nauman Ahmad et al. (2016) are consistent with our, demonstrating the effectiveness of Micro-Learning-based audio podcasts in enhancing student learning outcomes [29].

Conclusion

The current study provides empirical evidence that students engaged in Micro-Learning-based instruction exhibit a deeper comprehension, acquire a higher level of skill proficiency, and demonstrate greater knowledge and skills retention compared to their counterparts receiving traditional pedagogical methods.

As technology becomes more deeply ingrained in educational curricula, there is a fundamental reconsideration of educational methods underway. Recent research, including this study, underscores the effectiveness of Micro-Learning in enriching education programs. This suggests that integrating Micro-Learning could offer a valuable solution for updating the educational programs of the nurse anesthesia department, aligning them with the evolving demands of the field. This approach can foster a more dynamic and current teaching-learning process, leading to graduates with a stronger knowledge base and a more comprehensive skillset. Ultimately, this translates to improved patient care outcomes and contributes to a healthier population.

Limitations

While this study provides novel insights, it was faced with challenges and limitations that may have affected the generalizability and validity of its findings. For example, the small sample size may limit the applicability of the results to wider populations. Moreover, due to sample selection constraints, the convenience sampling method was employed, and the sample was collected from among students enrolled in only one university. This could hinder the generalizability of the results to other student populations with diverse demographic characteristics and educational backgrounds.

Despite the research team's efforts to prevent the storage and sharing of Micro-Content provided to the M-L M group, potential interactions between members of the two groups could have allowed for the transfer of knowledge from the M-L M group to the T M group. This could potentially confound the observed effect of the interventions. Additionally, this study did not provide the opportunity to explain the impact of Micro-Learning on the “Impact” level of Kirkpatrick's model, which makes it difficult to fully evaluate its effectiveness in changing the behavior of students at the bedside. This, in turn, could be a motivation for future research, along with investigating the generalizability of the findings of this study to other educational settings.

Ethical considerations

Ethical approval was obtained from the Research Ethics Committees of Ahvaz Jondishapur University of Medical Sciences (Reference Number: IR.AJUMS.REC.1402.349) before conducting the study. Prior to commencement of the intervention, the aims and procedures of the study were explained to eligible students. Participation in the study was voluntary, and individuals could withdraw at any stage. Written informed consent was obtained from all participants. The confidentiality of all test scores was maintained throughout the study. In the end, after completion of the study, members of the T M group were also invited to receive the educational content provided to the M-L M group, if they wished.

Suggestions

Despite Micro-Learning's high potential for enhancing the teaching-learning experience, there has been little research in this area, presenting significant opportunities for more research. This flexible approach is expected to be useful not only as a standalone method but also as an effective tool to enrich other new and even traditional educational methods. To explore this potential, Micro-Learning-based content can be utilized to provide educational materials for Flipped Classrooms and Project-Based independent activities, facilitate Self-Regulated learning during clinical internships, or organize Peer-to-Peer learning on the Internet platforms (through sharing students’ experiences in Micro-Content like brief voices). The impact of Micro-Learning on the quality of healthcare services received by patients is another unexplored area that can open up new avenues for further research. Additionally, further research is needed to delve into Micro-Learning's potential in

bridging theoretical knowledge with practical actions at the bedside.

On the other hand, it is worth mentioning that investigating the effectiveness of Micro-Evaluation (using concise tests or brief interactive assessments in Bite-Sized modules like Micro-Quizzes) alongside Micro-Learning in pinpointing students' strengths and weaknesses, while simultaneously measuring their knowledge and skills acquisition, also presents significant research opportunities to explore this phenomenon.

Acknowledgments

The authors express gratitude to faculty members and colleagues at Ahvaz Jundishapur University of Medical Sciences for their valuable input, as well as to the students whose participation contributed significantly to advancing knowledge in nurse anesthesia education, aiming to enhance the quality of educational programs and consequently improve healthcare.

References

[1] Wang JC, Yang TS, Chen PH, Huang WH, Hsiao SY, Wong CS, et al. Enhanced Perioperative Safety and Comfort During Airway-Related Surgeries and Procedures With Dexmedetomidine-A Brief Review and Clinical Practice Experience. Asian J Anesthesiol. 2018; 56(2):56-63.

[2] Hews J, El-Boghdadly K, Ahmad I. Difficult airway management for the anesthetist. Br J Hosp Med (Lond). 2019; 80(8):432-40.

[3] Patwa A, Shah A, Garg R, Divatia JV, Kundra P, Doctor JR, et al. All India Difficult Airway Association (AIDAA) consensus guidelines for airway management in the operating room during the COVID-19 pandemic. Indian J Anaesth. 2020; 64(Suppl 2):S107-s15.

[4] Haas L. Anesthesia care team risk: considerations to standardize anesthesia technician training. Aana j. 2013;81(2):121-6.

[5] Baillard C, Boubaya M, Statescu E, Collet M, Solis A, Guezennec J, et al. Incidence and risk factors of hypoxemia after preoxygenation at induction of anesthesia. Br J Anaesth. 2019; 122(3):388-94.

[6] Dabija M, Fedog F, Engström Å, Gustafsson S. Difficult Airways: Key Factors for Successful Management. J Perianesth Nurs. 2019; 34(1):151-9.

[7] Panchal AR, Way DP, King AM, Yudkowsky R, Terndrup TE. Performance Standards of Comprehensive Airway Management for Emergency Medicine Residents. AEM Educ Train. 2019; 3(1):39-49.

[8] Lee J, Lee Y, Gong S, Bae J, Choi M. A meta-analysis of the effects of non-traditional teaching methods on the critical thinking abilities of nursing students. BMC Med Educ. 2016; 16(1):240.

[9] Zarshenas L, Mehrabi M, Karamdar L, Keshavarzi MH, Keshtkaran Z. The effect of Micro-Learning on learning and self-efficacy of nursing students: an interventional study. BMC Med Educ. 2022; 22(1):664.

[10] Balliu V. Modern teaching versus traditional teaching-Albanian teachers between challenges and choices. European Journal of Multidisciplinary Studies. 2017; 2(4):20-6.

[11] Sedaghatkar F, Mohammadi A, Mojtahedzadeh R, Gandomkar R, Rabbani Anari M, Dabiri S, et al. Enhancing Medical Students' Knowledge and Performance in Otolaryngology Rotation through Combining Microlearning and Task-Based Learning Strategies. Int J Environ Res Public Health. 2023; 20(5).

[12] Yeleussizkyzy M, Zhiyenbayeva N, Ushatikova I, Lushkov R. E-Learning and Flipped Classroom in Inclusive Education: The Case of Students with the Psychopathology of Language and Cognition. J Psycholinguist Res. 2023; 52(6):2721-42.

[13] Vaona A, Banzi R, Kwag KH, Rigon G, Cereda D, Pecoraro V, et al. E- learning for health professionals. Cochrane Database of Systematic Reviews. 2018; 1(1).

[14] Prabu Kumar A, Omprakash A, Chokkalingam Mani PK, Kuppusamy M, Wael D, Sathiyasekaran BWC, et al. E-Learning and E-modules in medical education-A SOAR analysis using perception of undergraduate students. PLoS One. 2023; 18(5):e0284882.

[15] Deschênes MF, Goudreau J, Fontaine G, Charette M, Da Silva KB, Maheu-Cadotte MA, et al. Theoretical foundations of educational strategies used in E-Learning environments for developing clinical reasoning in nursing students: A scoping review. Nurse Educ Pract. 2019; 41:102632.

[16] Alfaleh R, East L, Smith Z, Wang SY. Nurses' perspectives, attitudes and experiences related to E-Learning: A systematic review. Nurse Educ Today. 2023; 125:105800.

[17] Regmi K, Jones L. A systematic review of the factors–enablers and barriers–affecting E-Learning in health sciences education. BMC medical education. 2020; 20:1-18.

[18] Díaz Redondo RP, Caeiro Rodríguez M, López Escobar JJ, Fernández Vilas A. Integrating Micro-Learning content in traditional E-Learning platforms. Multimedia Tools and Applications. 2021; 80(2):3121-51.

[19] Qian Q, Yan Y, Xue F, Lin J, Zhang F, Zhao J. Coronavirus Disease 2019 (COVID-19) Learning Online: A Flipped Classroom Based on Micro-Learning Combined with Case-Based Learning in Undergraduate Medical Students. Adv Med Educ Pract. 2021; 12:835-42.

[20] Jomah O, Masoud AK, Kishore XP, Aurelia S. Micro learning: A modernized education system. BRAIN Broad Research in Artificial Intelligence

and Neuroscience. 2016;7(1):103-10.
[21] Tira Nur F. Microlearning in Teaching and Learning Process: A Review. CENDEKIA: Jurnal Ilmu Sosial, Bahasa dan Pendidikan. 2022;2(4):114-35.
[22] Shail MS. Using Micro-Learning on Mobile Applications to Increase Knowledge Retention and Work Performance: A Review of Literature. Cureus. 2019;11(8):e5307.
[23] Sözmen EY, Karaca O, Batı AH. The effectiveness of interactive training and microlearning approaches on motivation and independent learning of medical students during the COVID-19 pandemic. Innovations in Education and Teaching International. 2021; 1360260:1–10.
[24] Clark RC, Mayer RE. E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning: Wiley; 2023.
[25] Delungahawatta T, Dunne SS, Hyde S, Halpenny L, McGrath D, O'Regan A, et al. Advances in E-Learning in undergraduate clinical medicine: a systematic review. BMC Med Educ. 2022; 22(1):711.
[26] Abdulrahaman MD, Faruk N, Oloyede AA, Surajudeen-Bakinde NT, Olawoyin LA, Mejabi OV, et al. Multimedia tools in the teaching and learning processes: A systematic review. Heliyon. 2020; 6(11):e05312.
[27] Dipiro JT. Why do we still lecture? Am J Pharm Educ. 2009;73(8):137.
[28] Ichiuji BA, DeAngelis EJ, Corpodean F, Thompson J, Arsenault L, Amdur RL, et al. The Effect of a Microlearning Module on Knowledge Acquisition in Surgery Clerkship Students. J Surg Educ. 2022; 79(2):409-16.
[29] Ahmad N, Al-Khanjari Z. Effects of audio podcasts as a micro learning tool on instruction. E-Leader Int J. 2016; 11(2):1–6.