Original Article

Investigating the Impact of Teaching Orthopedic Surgical Technology Course Using a Vertical Integration Approach on Learning Outcomes of Operating Room Students: A Semi-Experimental Study

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Abstract

Background: The primary objective of medical education is to cultivate competent individuals capable of achieving preventive and therapeutic goals and improving community health. To accomplish this, the employment of effective and efficient teaching methods for the precise and systematic organization of educational content is of paramount importance.

Objectives: The current research aimed to investigate the impact of implementing an orthopedic surgical technology training course using a vertical integration approach on learning outcomes, clinical skills, and satisfaction as educational outcomes among operating room students.

Methods: This semi-experimental study was of pretest-posttest type in which 52 fifth semester undergraduate operating room students were recruited using a convenience sampling method. Based on whether or not they had passed the theoretical credit of surgical technology course, they were assigned to the control (non-integrated) or intervention (integrated) groups. In the intervention group, the theoretical and practical topics of the orthopedic surgical technology course were taught using a vertical integration approach, while in the control group, training was conducted using the routine method. Before and after the training, learning outcomes and clinical skills in both groups of students were assessed and compared using a questionnaire and an observational checklist. The data were analyzed using the paired t-test, Wilcoxon test, and analysis of covariance (ANCOVA) in SPSS software.

Results: Based on the paired t-test results, implementing an orthopedic surgical technology training course using a vertical integration approach had a significant impact on learning outcomes and clinical skills in surgical technology ($P < 0.001$). The independent t-test results revealed that the level of satisfaction in the intervention group was significantly higher ($P < 0.001$). According to the results of the ANCOVA, the effectiveness of the vertical integration approach intervention on learning outcomes and clinical skills was reported to be significantly higher than the non-integrated group ($P < 0.001$).

Conclusion: Implementing an orthopedic surgical technology training course using a vertical integration approach can be considered an effective educational strategy that, in addition to improving learning outcomes, can culminate in improved clinical skills and satisfaction among students. Therefore, it is recommended that educational managers in the operating room department pay attention to this matter and provide the conditions for implementing integrated training in their centers.

Keywords: Vertical Integration; Satisfaction; Learning; Clinical Skills; Surgical Technologist

Background

Education is an essential and inseparable element of growth and development, and one of the most important strategies for ensuring success across all social dimensions (1). Medical education, as a type of education in the health system, is responsible for cultivating competent individuals to ensure community health. Since Flexner's time, this type of education has been designed in such a way that medical students first learn basic sciences and then clinical sciences (2). In recent decades, due to the inability of this educational approach to establish a connection between basic and clinical sciences for students, it has been criticized (3). Therefore, we have witnessed major transformations in the implementation of curricula and their reform toward concept-based educational programs. In implementing these programs, organizing materials for retrieval in similar situations and better consolidation of materials in long-term memory takes place better and easier, and learning theoretical topics is developed with a focus on their clinical practice (4, 5). The presentation of materials in concept-based educational programs with an integration approach gives rise to the organization of curricular materials that are often taught in separate courses or departments at the university (6). In this educational model, learning becomes enjoyable for learners due to the creation of a real and engaging learning environment (7). Thus, the achievement of educational goals is improved. Curriculum integration is implemented in two general forms: Horizontal and vertical (8). In horizontal integration, curricular topics that revolve around a common concept are taught together and around a central theme or concept (9). For example, professors from different departments address different aspects of respiratory diseases, including diagnosis, treatment, etc. However, in vertical integration, basic and clinical sciences are implemented simultaneously in such a way that, by implementing these educational programs, instead of being taught theoretical aspects in one semester and then the practical and clinical aspects of the same topics in another semester, students are required to receive and practice clinical cases related to that topic simultaneously with acquiring theoretical knowledge, according to the program and in the same semester (10). It is believed that vertical integration is a more efficient method than horizontal integration in clinical fields, culminating in a deeper understanding of basic sciences and facilitating the socialization of students in the medical profession (10, 11).

Numerous studies have demonstrated improved student attitudes toward basic sciences, deeper and more comprehensive learning, and the acquisition of higher-level skills following the implementation of vertical integration of courses in medical curricula (12, 13). However, research in other disciplines is very limited. One such group is surgical technology students, who complete their education in a four-year program in university classrooms and operating room environments. Undoubtedly, training competent students with a high level of knowledge and clinical skills can guarantee patient safety and achieving positive surgical outcomes (14), students who work closely alongside surgeons and, in some cases, one step ahead of surgeons to be able to satisfy the needs of surgery as quickly as possible and complete surgical procedures (15, 16). Achieving this goal requires recognition of the curriculum and effective teaching models, including the integration model, the benefits of which were discussed in the previous section. Obviously, training surgical technology students through a vertically integrated approach, in which they can practice and experience the knowledge they acquire in the classroom in conjunction with the real-world operating room environment, seems necessary (17). One of the main courses for operating room students is surgical technology courses in various surgeries, including orthopedic surgery, where students, in addition to theoretical familiarity with the anatomy and physiology of bones and orthopedic diseases, are required to recognize and apply specialized tools and equipment for performing various orthopedic surgeries and providing preoperative, intraoperative, and postoperative care in the role of a circulating nurse and scrub nurse. Currently, students take the theoretical aspects of the course in one semester and the practical aspects as an internship in the following semester. This separate presentation of the courses causes students to forget many of the topics during the semesters in which they are doing internships and face challenges in the operating room environment. Therefore, the present research aimed to determine the impact of implementing the teaching of the orthopedic surgical technology course using a vertical integration approach on students' learning outcomes, clinical skills, and satisfaction.

Objectives

The current research aimed to investigate the impact of implementing an orthopedic surgical technology training course using a vertical integration approach on learning outcomes, clinical skills, and satisfaction as educational outcomes among operating room students.

Methods

Study Design: This semi-experimental study as a pretest-posttest, two-group design with an intervention and a control group was conducted at Iran University of Medical Sciences in 2023-2024.

Participants: The sample consisted of 52 undergraduate students studying in operating room technology field of study, who were selected according to the inclusion criteria, including consent to participate in the study and either taking or having completed the orthopedic surgery technology theoretical course and the surgical technique internship course. Samples were assigned to either the control group (non-integrated, n = 24) or the intervention group (integrated, n = 28) based on whether they had completed the orthopedic surgery technology theoretical course.

Procedure: This research was designed and implemented in two phases: Design and intervention. In the design phase, the researcher collaborated with experts from the operating room, orthopedics, and medical education during several meetings to develop the educational objectives, implementation plan, and evaluation tools for the intervention group. Subsequently, in the intervention phase, the researcher held a meeting with students who met the inclusion criteria to explain the educational objectives of the course and the implementation process. Participants were then asked to complete a demographic information form and the learning pretest questions (consisting of 40 questions) within 30 minutes. Additionally, in both groups in the practical unit, a pretest of clinical skills was assessed using a researcher-developed checklist. These two scores, measuring learning outcomes and practical skills, served as the baseline assessment criterion (pretest) for the learners.

Then, based on the teaching course plan (Appendix 1), the intervention group received 14 sessions of case-based training using a vertical integration approach. This training involved theoretical training followed by clinical skills training at medical centers on relevant topics, such as anatomy and physiology, identifying specialized instruments and equipment in orthopedic surgery, examining bone pathophysiology, fracture management, and orthopedic diseases, examining upper extremity fractures, shoulder girdle fractures, thoracic fractures, lower extremity fractures, total knee, hip, and shoulder arthroplasty, ligament injuries of the knee and shoulder and their surgical management, and amputation.

In the practical training of the integrated group, an orthopedic patient on the operating room list was selected based on the educational objectives. The instructor (researcher) then explained the surgical procedure and technique. Additionally, instruments and equipment required in surgery were described, along with safety precautions. All preoperative, intraoperative, and postoperative care measures according to the patient's specific condition were also discussed. All taught content was practically repeated and reviewed with the students during the surgery.

The control group, which had completed the theoretical courses in the previous semester, participated in a surgical technique internship conducted in a routine manner under the supervision of the researcher. At the end of the internship, a posttest, involving assessments of learning outcomes and clinical skills, was administered to both groups of students to evaluate the impact of the curriculum on students' learning outcomes and clinical skills. Furthermore, a satisfaction survey regarding the teaching method was completed by students in both groups. The flowchart of the study is displayed in Figure 1.

Data Collection Tools: Data collection tools comprised a multiple-choice exam to assess learning, a checklist to evaluate clinical skills, and a questionnaire to measure student satisfaction. The multiple-choice exam on learning contained 40 questions in the domains of anatomy, terminology, physiology, pathophysiology, diagnostic tests and procedures, surgical attention and care, surgical instruments and equipment, surgical procedures, and postoperative procedures and care. The skill assessment checklist included 133 questions in the domains of scrubbing (hand washing), hand drying, gowning, closed gloving, gowning and gloving a surgeon, setting up the surgical table, identifying surgical instruments, prepping, draping, counting gauze, needles, and sponges, suturing, and removing gowns and gloves. Ultimately, the satisfaction questionnaire consisted of 20 questions to assess satisfaction with clinical and theoretical teaching methods and related items, academic motivation, teaching and management of issues, such as clinical judgment, self-confidence, communication skills, course content, and principles related to orthopedic surgery.

The scientific validity of all three tools was assessed using content validity and a survey of operating room and medical education experts, in such a way that in the qualitative content analysis, the researcher asked experts to assess the tools qualitatively and provide feedback, based on which the necessary modifications were made. In order to assess the reliability of the tools (questionnaire) in the learning and satisfaction sections, Cronbach's alpha coefficient was calculated and the internal consistency of the questions was determined, and their reliability was thus approved at 0.84 and 0.87, respectively.

To ensure the reliability of the clinical skills tool (observational checklist), the test-retest method using two raters was employed. The correlation between the scores given by the two raters was greater than 0.90. For the learning and skill sections, the content validity index (CVI) was 0.83 and 0.80, and the content validity ratio (CVR) was 0.82 and 0.85, respectively. Based on the Lawshe table, the tool's content validity was confirmed.

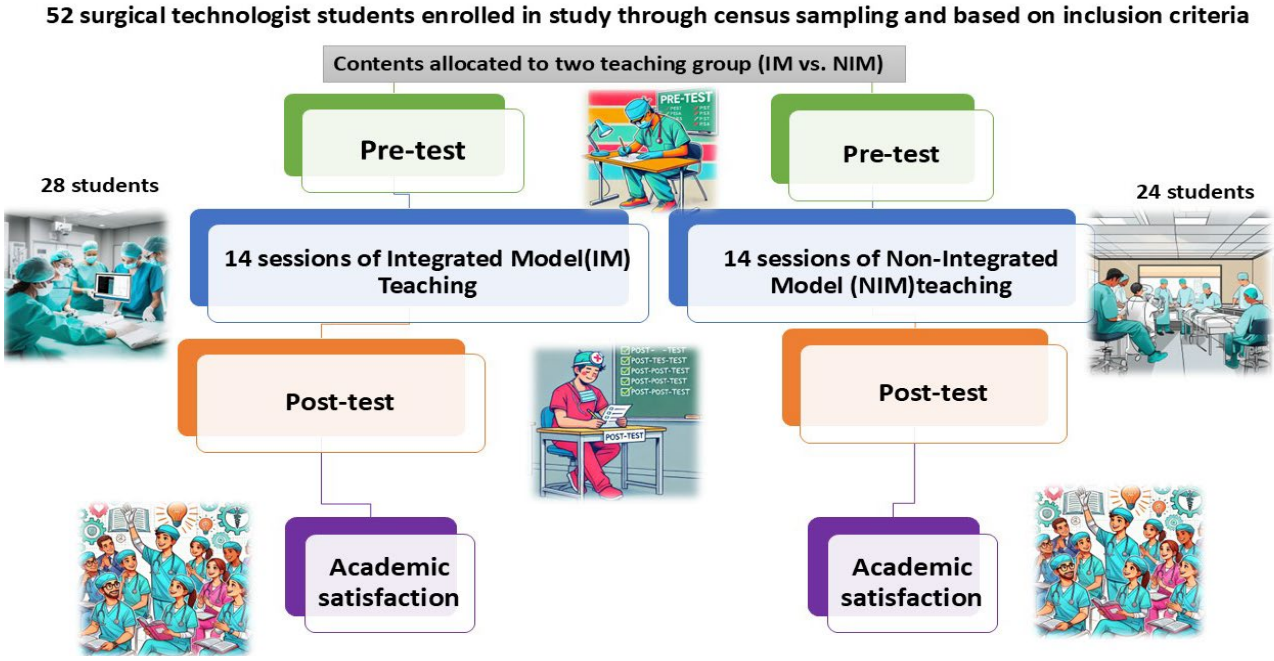

Figure 1. Flowchart of implementing an integrated and non-integrated educational program in the intervention and control groups

Data Analysis: The findings section first described the variables using means and standard deviations. A paired t-test was used to compare the within-group mean scores. The independent t-test was used to examine the level of satisfaction between the two groups. Additionally, analysis of covariance (ANCOVA) and multivariate analysis of covariance (MANCOVA) were employed to compare the effectiveness of the intervention on the two variables of learning outcomes and clinical skills. Moreover, the assumptions of parametric ANCOVA, including the absence of outliers, normal distribution of data, homogeneity of variances, homogeneity of regression slopes, and homogeneity of variance-covariance matrices, were examined and found to be met. Finally, the data were analyzed using SPSS version 28 (IBM Corporation, Armonk, NY). The significance level was set at $P < 0.05$.

Results

In the present study, the integrated group consisted of 28 individuals, and the non-integrated group comprised 24 participants. Results revealed that there were no significant differences between the two groups in terms of demographic characteristics, such as gender, grade point average (GPA), and age. In addition, based on the significance levels of Fisher's exact test and the independent t-test, which were higher than 0.05, it can be concluded that the two groups were homogeneous regarding gender, GPA, and age ($P > 0.05$). In terms of gender, most participants in both groups were female. The GPAs of the integrated and non-integrated groups were 16.78 and 17.25, respectively, which were similar. The mean age was 21.61 years in the integrated group and 21.42 years in the non-integrated group, which were similar. A description of learning and its components in the two groups is presented in Table 1, and the mean posttest and pretest times were compared using a paired t-test (within-group comparison).

The results of Table 1 demonstrated that the mean score of learning in the integrated group was 5.16 in the pretest. In the posttest, the mean score of learning demonstrated a substantial increase of 11.38 points, reaching to 16.54. In the integrated group, the mean posttest time increased in all three learning components so that in basic skills, it increased from 2.14 to 6.55. In surgical procedures, this score increased from 2.04 to 7.77, and in preoperative and postoperative care, it increased from 0.98 to 2.21. Moreover, the mean score of learning in the non-integrated group was obtained to be 10.90 in the pretest. In the posttest, the mean score of learning demonstrated a substantial increase of 1.45 points, reaching to 12.35. These findings indicate a smaller increase in learning outcomes in the non-integrated group compared to the integrated group.

Table 1. Comparing the results of learning components at two time points between integrated and non-integrated groups using the paired t-test

Variable	Time	Integrated Group		Non- integrated Group	
		Mean (SD)	**P-value**	**Mean (SD)**	**P-value**
Basic skills	Pretest	2.14 (1.45)	< 0.001	4.73 (0.83)	0.524
	Posttest	6.55 (1.20)		4.79 (0.75)	
Surgical procedure	Pretest	2.04 (1.65)	< 0.001	4.44 (1.41)	0.009
	Posttest	7.77 (1.46)		5.50 (1.10)	
Preoperative and postoperative care	Pretest	0.98 (0.76)	< 0.001	1.73 (0.39)	0.003
	Posttest	2.21 (0.50)		2.06 (0.37)	
Learning score (total)	Pretest	5.16 (3.42)	< 0.001	10.90 (2.12)	0.003
	Posttest	16.54 (2.61)		12.35 (1.51)	

SD: Standard deviation

The results of the paired t-test revealed that in both the integrated and non-integrated groups, the mean scores of learning and all components were significantly higher in the posttest than in the pretest ($P < 0.050$).

Table 2 presents a description of clinical skills and their components in the two groups. The mean posttest and pretest times were compared using a paired t-test (within-group comparison).

The results of Table 2 revealed that the mean score of clinical skills in the integrated group was 203.18 in the pretest. In the posttest, the mean score of clinical skills demonstrated a substantial increase of 234.82 points, reaching to 438.00. In the integrated group, the mean posttest time increased for all 12 indicators of clinical skills.

In the non-integrated group, the mean score of clinical skills was 289.54 in the pretest. In the posttest, the mean score of clinical skills demonstrated a substantial increase of 93.96 points, reaching to 383.50, which indicates a significant increase in clinical skills in the posttest. Moreover, the mean posttest time increased for all 12 indicators of clinical skills. Based on the paired t-test results, the mean scores of clinical skills and all its 12 indicators were significantly higher in the posttest than in the pretest in both the integrated and non-integrated groups ($P < 0.050$).

Table 2. Comparing the results of clinical skills component at two time points between integrated and non-integrated groups using the paired t-test

Variable	Time	Integrated Group		Non-integrated Group	
		Mean (SD)	**P-value**	**Mean (SD)**	**P-value**
Scrubbing	Pretest	69.82 (10.41)	< 0.001	89.67 (18.43)	< 0.001
	Posttest	129.21 (13.27)		114.75 (15.72)	
Hand drying	Pretest	12.04 (1.26)	< 0.001	14.67 (2.10)	< 0.001
	Posttest	17.79 (1.75)		17.75 (1.33)	
Gowning	Pretest	10.14 (0.76)	< 0.001	15.38 (2.37)	< 0.001
	Posttest	19.79 (0.83)		18.08 (1.84)	
Closed gloving	Pretest	19.50 (1.73)	< 0.001	28.83 (4.54)	< 0.001
	Posttest	34.21 (2.62)		33.63 (3.49)	
Gowning and gloving a surgeon	Pretest	8.36 (1.34)	< 0.001	10.67 (2.16)	< 0.001
	Posttest	13.82 (1.49)		13.12 (2.47)	
Setting up the surgical table	Pretest	10.93 (5.13)	< 0.001	29.25 (3.15)	< 0.001
	Posttest	53.54 (4.79)		42.58 (4.76)	
Identifying surgical instruments	Pretest	8.64 (4.97)	< 0.001	21.17 (2.53)	< 0.001
	Posttest	45.43 (4.01)		34.96 (4.96)	
Prepping	Pretest	19.11 (3.78)	< 0.001	21.17 (3.80)	< 0.001
	Posttest	38.14 (2.98)		32.42 (5.48)	
Draping	Pretest	11.96 (3.70)	< 0.001	16.04 (3.07)	< 0.001
	Posttest	25.64 (2.82)		22.04 (2.93)	

Counting gauze, needles, and sponges	Pretest	8.68 (1.34)	< 0.001	11.58 (1.93)	< 0.001
	Posttest	17.32 (1.66)		14.50 (2.86)	
Suturing	Pretest	14.79 (2.92)	< 0.001	18.92 (2.80)	< 0.001
	Posttest	26.21 (3.28)		24.29 (2.26)	
Removing gowns and gloves	Pretest	9.21 (1.69)	< 0.001	12.08 (1.64)	< 0.001
	Posttest	16.89 (1.47)		15.38 (1.38)	
Clinical skills (total score)	Pretest	203.18 (23.49)		289. 54 (35.72)	< 0.001
	Posttest	438.00 (29.94)		383.50 (36.59)	

SD: Standard deviation

Table 3. The results of the analysis of covariance to compare the effectiveness of the intervention on learning outcomes and clinical skills

Source of Variation	Dependent Variable	Comparison of Mean Scores	F		P-Value	Effect Size
		Mean Difference*	SD			
	Basic skills	1.97	0.43	21.28	< 0.001	0.312
	Surgical procedure	1.77	0.52	11.63	< 0.001	0.198
	Preoperative and postoperative care	0.10	0.18	0.31	0.584	0.006
	Learning score (Total)	3.59	0.86	17.47	< 0.001	0.263
	Scrubbing	47.91	6.63	52.14	< 0.001	0.578
	Hand drying	3.08	1.01	9.34	0.004	0.197
	Gowning	4.44	0.84	27.69	< 0.001	0.421
	Closed gloving	6.39	2.31	7.64	0.009	0.167
Group	Gowning and gloving a surgeon	5.05	1.20	17.83	< 0.001	0.319
	Setting up the surgical table	13.47	4.15	10.55	0.002	0.217
	Identifying surgical instruments	17.79	3.55	25.06	< 0.001	0.397
	Prepping	11.42	3.17	12.98	< 0.001	0.255
	Draping	8.53	1.86	21.11	< 0.001	0.357
	Counting gauze, needles, and sponges	3.89	1.46	7.09	0.011	0.157
	Suturing	3.10	2.75	1.27	0.267	0.032
	Removing gowns and gloves	4.19	1.25	11.18	0.002	0.227
	Clinical skills (total score)	133.98	9.38	204.15	< 0.001	0.806

SD: Standard deviation

*The difference in mean scores refers to the adjusted posttest mean score after controlling for the pretest score of the variable in the two groups.

Table 3 presents the ANCOVA results to compare the effectiveness of the two teaching methods on learning outcomes and clinical skills. ANCOVA was used for the total scores of the variables, and MANCOVA was used for the components.

Table 3 presents the results of the ANCOVA, indicating that the intervention was effective in improving learning outcomes and clinical skills ($P < 0.050$). The significance level for the total scores of learning outcomes and clinical skills was less than 0.05., suggesting that the integrated group had a significantly greater impact on the improvement of learning outcomes and clinical skills was than the non-integrated group. A comparison of effect sizes using partial eta-squared revealed that the intervention's impact on the improvement of clinical skills was greater than that on learning outcomes (0.806 versus 0.263). The findings confirmed the integrated group's impact on the two learning components, including basic skills and surgical procedure, as well as on all components of clinical skills except for suturing ($P < 0.050$). Effect size values reported that the highest intervention effectiveness among learning components was related to basic skills (coefficient = 0.312), and among components of clinical skill, it belonged to scrubbing (coefficient = 0.578), gowning (coefficient = 0.421), and identifying surgical instrument (coefficient = 0.397).

Table 4 compares the levels of satisfaction of the two groups using an independent t-test. Level of satisfaction was measured once, after the intervention. The comparison of satisfaction in Table 4 showed that the level of satisfaction was 82.11 in the integrated group and was 67.25 in the non-integrated group, with a mean difference of 14.86, indicating higher satisfaction in the integrated group. According to the independent t-test results, the level of satisfaction was significantly higher in the integrated group than in the non-integrated group ($P < 0.050$).

Discussion

Based on the present study results, the implementation of an orthopedic surgical technology training course using a vertical integration approach significantly impacted learning outcomes, clinical skills, and satisfaction of surgical technology students so that a significant difference was observed in the mean scores of learning tests, clinical skills, and satisfaction among the two groups.

Table 4. Comparing levels of satisfaction between the integrated and non-integrated groups using the independent t-test

Independent Variable	Integrated Group	Non-integrated Group	P-Value
	Mean (SD)	Mean (SD)	
Satisfaction	67.25 (10.56)	82.11 (11.41)	< 0.001

SD: Standard deviation

The findings of the present study align with those of Mattout et al.'s research, conducted to investigate the use of a realistic simulation scenario as a vertical integration teaching tool for medical students. The researchers reported in the mentioned research that this teaching method facilitated memorization and better learning (18). Daniel and Joseph, in Pennsylvania, also examined the impact of horizontal integration in nursing curriculum and concluded that the integration teaching method culminated in a better understanding of concepts and increased interactive learning (19), which is consistent with the results of the present study. The findings of Dulloo et al.'s study, which was conducted to investigate the effect of horizontal and vertical integration on students' learning and perception (20), were also consistent with the results of the present study. Sadati et al.'s study, conducted aiming to compare two task-based and routine teaching methods in terms of students' knowledge, explained that the level of awareness among students had increased and that the implementation of new training method was effective in learning (21). The mentioned study yielded similar results and was consistent with the findings of the present study. By evaluating the implementation of vertical integration of the pathology course in medical students studying in the three first years, Bhatti et al. stated that most students, after the implementation of vertical integration of the pathology course, considered it effective in achieving the course objectives and reported that this method helped them to gain a better conceptual understanding of the main topics in pathology (22).

In clarifying the materials mentioned above, it can be concluded that the implementation of innovative educational programs, particularly the integrated approach, can significantly enhance the quality of learning and knowledge acquisition among students. In this integrated educational method, students have better opportunities through objective observation and can apply and solidify their understanding of concepts through clinical experiences.

The findings of the present study revealed that students' clinical and practical skills also improved due to increased self-confidence, surgical management, interpersonal communication, and a higher level of knowledge. The results of Wijnen-Meijer et al.'s research, aimed at determining the performance differences between graduates of vertical integrated and non-integrated curricula (11), were consistent with the findings of the present study. They reported that the active professional development and performance of students in the integrated group were more reliable. Additionally, Yousefi et al.'s study, which investigated the impact of feedback-based training on intravenous line insertion skills, reported a significant improvement in students' intravenous line insertion skills (23), further supporting the usefulness of the proposed innovative educational approach and being consistent with the findings of the current study.

In Ebrahimpour and Imanipour's study, aimed at establishing a connection between theoretical knowledge about the concept of pain and its practical application in the format of a game-based competition among nursing students, it was reported that skills such as time management, optimal utilization of equipment and facilities, and teamwork improved, and This type of planning was accompanied by an improvement in quality (24). These findings were similar to the results of the present study. Training theoretical concepts in integration with practical concepts, due to the simultaneous engagement of the learner with a real-world situation consistent with Kolb's learning theory, provides a condition for the learner to have an easier and better understanding of the material in similar situations

(25). This leads to better learning of procedures and acquisition of skills. The results of Sadati et al.'s study on the education of surgical residents through the design of educational boot camps that included teaching and practicing basic surgical skills (26) support this finding.

Our findings regarding student satisfaction with teaching through the integrated approach also demonstrated an increase in student interest. Additionally, students reported a growth in their academic motivation. In a survey, students attributed this increased satisfaction to improved clinical performance, enhanced power of clinical judgment, and a better understanding of the taught material. Ultimately, they recommended this teaching method to their peers. The results align with the research conducted by Amini et al. to investigate the effect of integrating basic and clinical aspects on student satisfaction with the integrated teaching approach (10). Both studies highlighted the effectiveness of integrated approach in fostering academic motivation and a positive learning incentive. Similarly, Chhabra et al.'s research, aimed to investigate the effect of vertical integration in teaching, reported this training approach to be highly beneficial and advocated for conducting courses using this approach (6). Our findings corroborate these results. Daniel and Joseph also described this innovative approach as groundbreaking. They reported a 100% attendance rate, which they attributed to increased student motivation (19). These findings are consistent with our research.

Overall, a comparison of the effectiveness of the integrated and non-integrated methods using ANCOVA revealed that the integrated group showed significantly higher effectiveness in improving learning and clinical skills compared to the non-integrated group. However, results from some studies demonstrate that if there is insufficient preparedness among professors and students, and if inappropriate content is selected for integration, it may not only be ineffective in improving learning but may also culminate in student dissatisfaction due to increased engagement time (27). Therefore, the selection of appropriate content related to the internship in the present study appears to be one of the strengths in introducing the vertical integration approach in teaching undergraduate operating room courses, which can serve as a model for professors in Iran and other countries with similar educational programs.

Limitations: The small sample size in both groups and the fact that the internships were conducted in different operating rooms, which could have been influenced by varying educational atmospheres and impacted student learning outcomes and satisfaction, which was beyond the researchers' control, were among the limitations of this study. Additionally, despite advising students against sharing data, due to interactions among students, data exchange may have occurred in some cases, which was beyond the researchers' control. Another limitation of this study was the teaching method of theoretical materials in the control group, in which the researchers had no involvement in its design and only relied on the lesson plan provided by the respective professor, with all content being in accordance with the relevant curriculum.

Conclusion

The present study results demonstrated that the implementation of an orthopedic surgical technology training course using a vertical integration approach can serve as an effective educational strategy, not only enhancing learning outcomes but also improving clinical skills and student satisfaction. Therefore, it is recommended that this training approach be considered by administrators and executive officials in the education of operating room technology students in order to enhance learning, improve skills, and ensure patient safety.

Supplementary Material(s): is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

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Conflict of interests: There is no conflict of interest.

Ethical approval: The present study has been extracted from a master's thesis in Operating Room, approved by Iran University of Medical Sciences (ethics code: IR.IUMS.REC.1402.548).

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Appendix 1. Daily Lesson Plan Structure

Academic Year: 2023-2024	**Course Presentation Date: 04/10/2023**
Faculty: Paramedical Sciences	Course Type: Theoretical
Degree/Field of Study: Bachelor of Science in Operating Room	Instructor: Yaghmaei
Course (Credit) Title: Orthopedic Surgical Technology and Related Care	Number of Students: 28
Semester : 5	Class Duration: 120 minutes

Main Source of the Lesson:
Sadati, Leila. Golchini, Ehsan. Digestive and endocrine technology. Jame'e Negar Publications, 2015

Supplementary Learning Sources:
Surgical technology for the surgical technologist: A positive care approach /Association of Surgical Technologists / Cengage Learning; last edition /
Berry & Kohn's Operating Room Technique / Nancymarie Phillips RN PhD RNFA CNOR (Author) / Mosby; last edition

Educational Facilities: Whiteboard, video projector, instructional videos, mobile phone, laptop

Course Title: Orthopedic Surgical Technology and Related Care

Major Course Objective: To familiarize students with the concepts related to orthopedic surgery. (This session: Upper extremity fractures)

Minor Objectives:
- Describe the anatomy of bone, tendon, and joint tissues in the upper extremities.
- Explain the pathophysiology of joint and bone diseases in the upper extremities.
- Describe the most common fractures in the upper extremities.
- List the specialized instruments and equipment used in upper extremity surgeries.
- Compare the fracture surgical techniques and repair methods for in various upper extremity surgeries.
- Explain the roles of the circulating nurse and scrub nurse in the surgical process of upper extremity surgeries.

Describe the preoperative, intraoperative, and postoperative care for patients undergoing upper extremity surgery.

Teaching Method: Interactive, case-based teaching

Lesson Components and Presentation Methods: The lesson components and presentation methods are performed through a combination of various media formats, including PowerPoint presentations, educational videos, images, etc., depending on the specific content and established learning objectives.

Duration: 10 minutes	**Introduction**
• **Course Overview** ▪ Part I of the lesson ▪ Question and Answer and Rest ▪ Part II of the lesson	Duration: 20 minutes Duration: 30 minutes Duration: 30 minutes
Summary and Conclusion	Duration: 15 minutes