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Original Article

Evaluation of an Epidemiological Skills Laboratory Course Using a Direct Teaching and Online Flipped Classroom Method in Iran: An Interventional Study

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Abstract

Background and aims: The epidemiological skills laboratory (ESL) course has been incorporated into the curriculum for Master of Science students in epidemiology. However, it has not been implemented and evaluated in Iran so far. The present study was conducted to compare two teaching methods and the implementation of an ESL lesson.

Methods: All MSc students (N = 9) in epidemiology at Shahrekord University of Medical Sciences were included in the study during two academic semesters in 2019-2020 using a census sampling method. Three levels of Kirkpatrick's pyramid were used to evaluate direct teaching and electronic flipped classroom (FC) groups. The Chi-square test, Fisher's exact test, paired *t*-test, and independent t-test were used in Stata software with a significance level < 0.05.

Results: The means ± standard deviations (SD) of scores of pre- and post-instructional interventions were 42.1 ± 8.4 and 96.6 ± 2.1 in the intervention group with the FC method and 41.3 ± 3.2 and 77.3 ± 4.7 in the direct teaching group. The means ± SDs of satisfaction scores of pre- and post-instructional interventions were 67.8 ± 1.6 and 97.6 ± 5.6 in the intervention group with the FC method and 45.3 ± 5 and 87.3 ± 4.5 in the direct teaching group.

Conclusion: Under the conditions of the coronavirus disease 2019 epidemic, mainly the virtualization of students' education and easy access to virtual education systems to convey instructional content, it is a pleasurable opportunity to use the electronic FC method to teach students. The FC method could improve the students' epidemiological skills and increase their satisfaction.

Keywords: Epidemiology, Curriculum, Education, Competency-based education

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Introduction

Epidemiology is the science used to study how diseases and their associated risk factors are distributed in a population. It has an old history, and more than one hundred definitions have been proposed since 1978. The scope of this science is vast, and it is the methodological reference for medical science research and health promotion in society.[1,2] Epidemiology has several fields of study, as well as other disciplines in the medical sciences domain.[3] This discipline aims to train college graduates with the ability and skills to provide health, prevention, management, education, research, and counseling services and help make executive decisions to promote community health. They must be able to analyze and interpret health data, such as an epidemic or a disease, collaborate on health data quality control activities, and train experts in the healthcare sector at various levels.[3,4] They are also expected to be able to share the data obtained in the health area, such as primary healthcare, universal health coverage, and social health determinant.[5,6]

In the new curriculum of the Master of Science (MSc) in the epidemiology course at medical universities in Iran, the epidemiological skills laboratory (ESL) course has been added as an optional course to train and increase the skills required by the students. This course did not exist in the previous curriculum of this discipline. Shahrekord University of Medical Sciences is the first university that has offered an MSc in Epidemiology in Iran to include the optional course "ESL" in the academic program for MSc students in Epidemiology since 2015. As instructional design has yet to be provided for this course, scientific and evidence-based design, instructional intervention, and assessment are essential. Due to the occurrence of the COVID-19 epidemic in the world and Iran and

the simultaneous implementation of this work, it was necessary to consider a method appropriate to the virtualization of teaching classes and the limitations of the epidemic conditions in the design and implementation of epidemiology education. The COVID-19 epidemic has had a significant impact on education. The closure of schools and universities and the cessation of face-to-face classrooms have affected schools and students worldwide.[7]

Considering the development of and access to information and communication technology, new teaching methods, such as the electronic flipped classroom (FC) method, have been proposed, which can implement the teaching-learning process and lead to greater student satisfaction and better effectiveness.[8] The FC method comprises self-directed, asynchronous pre-course learning, followed by knowledge application and ESL training during electronic sessions. The existing evidence supports the effectiveness of this approach for the acquisition of cognitive skills; of course, under COVID-19 epidemic conditions and mainly the virtualization of students' education and easy access to virtual education systems to convey instructional content, it is a desirable opportunity to utilize the electronic FC method to teach students.[9,10]

Considering the curriculum of the MSc program in epidemiology and the repetition of different skills in various epidemiology courses at the master's degree level with 33 credits and the objection of some students, it is essential to select and present the content of the mentioned course such that the syllabus is observed and the transfer of epidemiological skills to students is facilitated. The students master the desired skills at the end of the semester to avoid excessive overlap in teaching some courses. The ESL course has been incorporated into the curriculum for MSc students in epidemiology. However, it has yet to be implemented and evaluated in Iran in a systematic way and with a proper instructional design to eliminate the existing gap between knowledge and performance. Therefore, the present research was conducted to investigate and incorporate the ESL course into the curriculum for MSc students in epidemiology using the electronic FC method and direct teaching.

Materials and Methods

This study is a combination of education research. This quasi-experimental study used an interventional pretest and posttest design with a control group. This study was performed to design, implement, and evaluate the ESL course among all MSc students in epidemiology at Shahrekord University of Medical Sciences within two academic semesters in 2019-2020. All students (n = 9) were included in this study; six students were assigned to the intervention group of online FC of the epidemiology laboratory, and three students were included in the control group of the epidemiology laboratory course with the direct teaching method. The control group consisted of a previous cohort of students enrolled in the same course but taught with a direct teaching approach. The direct teaching or traditional lecturing method consists of didactic PowerPoint presentations and activities such as multiple-choice questions and exercises to complete at home after class. The ease of use of available resources and facilities was provided by holding sessions in the Department of Epidemiology and Biostatistics, School of Health of Shahrekord, coordinating with the Research and Education Development Center of the University, and concluding a memorandum of understanding between the above-mentioned department and Modeling in Health Research Center of Shahrekord University of Medical Sciences. This research was conducted through design, implementation, and evaluation. The details of these three phases are introduced in the next paragraph.

The samples consisted of all students who had selected the ESL course. During the academic semester in which the online FC method was presented, two sessions of instructional interventions were held in person. Most classes were held online in cyberspace on the university's virtual education system platform due to the COVID-19 epidemic. The inclusion criteria for the intervention group included being an MSc student in epidemiology at Shahrekord University of Medical Sciences, having a profile in the SAMA system, signing the informed consent for participating in the study, completing the project questionnaires, and selecting the epidemiology laboratory course with the online flipped teaching method in the first semester in 2020. The inclusion criterion for the control group was selecting the epidemiology laboratory course with the direct teaching method in the second semester of 2019.

Educational Interventions

First, an educational needs assessment of the epidemiological skills required by an MSc graduate in epidemiology was collected from different resources through a rapid study based on the instructional curriculum review, text investigation, and review of websites. Other resources were instructional programs of reputable epidemiology departments at other universities in the world, the experience of working in the health system, interviews with experienced epidemiologists, a survey of epidemiology students and graduates, researchers, instructors, and managers of the health system, and 70 skills.

To select prioritized skills as instructional interventions, first, students were asked through a survey form to give each of the 70 epidemiological skills a score from 1 to 5 on a Likert-type scale based on their importance, application, and needs to be learned. The skills scored by the students and instructors were then listed in order of priority. A session was held again with students and other beneficiaries, and 23 main priorities and skills required by students were extracted from the determined priorities. These skills were considered instructional syllabi in the academic semester.

Design Phase

Forming the design committee of education through the electronic FC method was the most crucial step in the first phase. First, the instructional design committee, which consisted of a thematic specialist, content production specialist, and instructional designer, was formed. During several sessions, the teaching committee discussed different dimensions of this process in various axes, including conducting a needs analysis through a survey of participants, objectives, presenting in the form of the FC, presentable content, how to implement interactive lessons and scenario designing, participatory discussions on the learning management system (LMS), how to provide feedback to participants, and how to evaluate the process.

Instructional Content Production Process

The other steps were performed in this phase, including forming a design and content production team, which consisted of medical education specialists, epidemiologists, content specialists, and content production specialists. To produce standard content, this team went through other steps, including planning for a content production project and compiling the initial text of the content and the required authentic resources.

The instructional design of the content was performed based on the introduced model or pattern at the end of this manuscript. First, the teaching model was determined using the FC method; the instructor then examined its validity, and finally, it was implemented. For instructional design to be proportional to debate, the 3C model was used, which was introduced by Kerres and de Witt in 2003. This model includes content, communication, and participatory components; a content component provides learners with factual learning content, and a communication component makes the interpersonal interactions between learners or learners and instructors for complex and arguable learning tasks possible. In addition, a participatory component facilitates learners' active engagement in complex learning tasks. The following steps were performed in the instructional design of this study:

1. Audio and multimedia clip-making
2. Content curation
3. Content production using a power soft Screen Recorder Pro Portable Software package
4. Step-by-step and final evaluation of the produced content
5. Preparation of metadata and storage of prepared files in the archive of the university's epidemiology laboratory
6. Technical control and content presentation in the virtual education system of Shahrekord University of Medical Sciences
7. Students' awareness of how the process is going to be implemented using the electronic FC method.

For this purpose, the students were informed about the lesson implementation instructions in an electronic FC. Moreover, a detailed explanation was provided to students on how to study and review the instructional contents and how to take pretests and posttests and the lesson implementation process. Additionally, the relevant multimedia file was uploaded and made available to students in the university's virtual education system to inform them.

Program Implementation Phase

Considering the information obtained from the previous phase, the instructional course plan, including instructional syllabi, how to hold the course in the form of an electronic or online FC, and how to evaluate students, was announced to all epidemiology students as the target group of the study. The announcements and their links were posted on the website of the Modeling in Health Research Center, Department of Epidemiology and Biostatistics, School of Health, and other virtual networks, as well as advertising banners in the faculty and program center. The students admitted to the university for at least two academic semesters were registered through the Internet registration form of the SAMA system. The training course was conducted based on a predetermined curriculum with the invitation of experienced professors in this field and the formation of a team of instructors using an FC method. Finally, the students were evaluated according to the method specified in the first phase.

In the electronic or online FC, a different form of in-person classroom, teaching takes place before class. To learn the content, the students use educational movies. The students were provided with the content by posting instructional content on the university's virtual education system (i.e., LMS).

Considering the prevalence of the COVID-19 pandemic and the combination of in-person and online education, this teaching method has been relevant and suitable in the current conditions. Therefore, the in-person online classes were allocated to group activities, questions and answers, and interactions between professors and students.

FC had three main phases, including content preparation and students' study, readiness assessment, practicing skills by the student semi-independently and independently and conducting direct observation of practical skills and giving feedback for performing the right work and teamwork, interaction and provision of feedback.

In the first stage of the present study, the instructor recorded his lecture and provided it to students as a multimedia file. The students were then asked to listen to these lectures, investigate them at home as a pre-class homework assignment, and make the classroom an environment where the main learning activities occur. In other words, the lecture was transferred from the classroom to home, and the learning activities were moved from home to the classroom, which is considered a valuable learning environment. The teaching process through the FC method was divided into three phases and performed accordingly. The first phase is before class time, which is

conducted by assigning an activity as homework. In this stage, the student's task was to watch and study the videos provided to him by the instructor to get acquainted with the concepts and understand them. Formative assessment was used at this stage to ensure the students completed their homework. In the next stage, during the online class, when high levels of cognition occur, the students are engaged in problem-solving activities and discussions in small groups. Formative assessment was also utilized at this stage to control the students' learning activities. In the post-class stage, the students combined what they learned before and during the online class, used their creativity, and implemented a project. This method was suggested to improve the quality of the FC in authentic resources.[10,11] In this method, each student independently used a video or recording at home to film each class debate. The students had not been taught alone, the classroom attendance section had not been canceled, and the primary learning had occurred in groups and the classroom in person, or virtually.[12,13]

Description of Instructional Intervention

The instructional interventions were implemented in an electronic or online FC through the following three phases:

1. *The students' pre-class activities at home:* (*a*) Studying the introduced and available online course materials weekly, (*b*) Watching videos uploaded on the LMS
2. *Activities in online and virtual classes:* (*a*) Posing questions about the previous session's debates, (*b*) Participating (on the part of the students) in reviewing and completing answers provided to questions and quizzes, (*c*) Listening to the instructor's short lecture, (*d*) Observing practical activity, (*e*) Practicing and repeating practical activity
3. *Post-class activities:* (a) Reviewing difficult materials, (*b*) Practicing and preparing a video file about the class held, (*c*) Posing questions, talking, and exchanging ideas in the LMS forum.

Program Evaluation Phase

The ESL course for MSc students in epidemiology at Shahrekord University of Medical Sciences was evaluated based on Kirkpatrick's pyramid. Three levels of this pyramid were used for evaluation in this study. Students' reactions in the electronic class were evaluated and measured at the first level. Then, the participant's satisfaction with the structure and content of the course was surveyed and determined using a designed form with appropriate validity and reliability. At the second level, learning tests and academic achievement scores were used for learning. At the third level, accurate performance tests and direct observation of practical skills were utilized to assess skills. Learning assessment and pretest and posttest skill assessment were applied during the semester. Teaching this course using the direct teaching methods was also evaluated within a semester, and this group was used as a control group. Moreover, the preset-posttest design with the control group was employed to make comparisons. In addition to using accurate performance tests, the student self-report (perceptual or visual skills) for the implementation and mastery of skill implementation was utilized to measure epidemiological skills.

Description of Data Collection Tools and Pre- and Post-intervention Evaluation

The data were collected using a checklist, a learning test, and two research tools, namely, the Imaginary Performance Scale and the Student Satisfaction Questionnaire. As the questionnaire tool to evaluate the epidemiology laboratory course has yet to be developed so far, the researchers developed this tool in the following way:

First, a question bank (items) was prepared using qualitative interviews with various people, including professors of epidemiology and biostatistics, graduates, and students of epidemiology, and reviewing authentic texts, including reports from the Council of State and Territorial Epidemiologists of the United States. Next, the items' content validity and the questionnaires' face validity were evaluated, and the experts' opinions about the items were collected for this purpose. Finally, this questionnaire was evaluated in the panel of experts by six relevant experts regarding content. A total of 23 and 22 items were selected for the epidemiological skills assessment questionnaire for the intervention and the student satisfaction assessment questionnaire, respectively, and the qualitative and quantitative validity of the questionnaire underwent examination. To investigate the content validity of the questionnaire, content validity index (CVI) and content validity ratio (CVR) were used. CVR was calculated by dividing the number of experts who selected the item as an essential item minus the total number of experts divided by 2 by half of the total number of the experts. The CVR calculation formula is as follow:

$$CVR = (N_E - N/2) / (N/2)$$

N_E denotes the total number of experts who selected the essential option, and N is the total number of experts. This coefficient was obtained above 99% for the applied questionnaires.

The item's necessity and specificity, simplicity, fluency, and clarity were among the essential criteria for the evaluation. Each student completed the 23-item epidemiological skills measurement questionnaire at most two times (pre-intervention and post-intervention) and scored items on a 5-point Likert-type scale ranging from very low to excellent. The range of attainable scores from the Skills Measurement Questionnaire was 23–115. Each student also completed the 24-item students' satisfaction measurement questionnaire at most two times (pre-intervention and post-intervention) and scored items on a 5-point Likert-type scale ranging from very low to excellent. The range of attainable scores from the Satisfaction

Measurement Questionnaire was 24–120. The reliability of the questionnaires was calculated using Cronbach's alpha coefficient in a pilot study with a sample size of 5 for all completed questionnaires. The reliability of the 23-item epidemiological skills measurement questionnaire was estimated at 0.95 in the pilot study and 0.97 in the main study. Cronbach's alpha coefficient was determined as 0.87 in the pilot study and 0.85 in the primary research for the 24-item satisfaction measurement questionnaire.

Statistical Methods

The comparison of students, pre- and post-intervention comparison, and the control group comparison were used to control the confounding variables. Each student was considered the control sample for self. The data were analyzed using descriptive (means, standard deviations (SD), minimum, maximum, frequencies, and percentage indices) and analytical statistics using the Chi-square test, Kolmogorov-Smirnov test, Fisher's exact test, paired *t* test, independent t-test, and Wilcoxon test. The data were analyzed in Stata software with a significance level < 0.05. Considering the small sample size, the significance level was determined using the Monte-Carlo simulation method through 10 000 times sampling and calculating the *P* value to increase the accuracy.

Results

The mean ± SD of the student's age was 4.8 ± 37.7. There was no statistically significant difference ($P > 0.05$) between the two groups regarding age, gender, and bachelor's degree. About 55.6% of the students were female and 44.4% were male. Approximately 72.2% were married, and 27.8% were single. Nearly 38.9% of the students had *a* bachelor's degree from Shahrekord University of Medical Sciences, and 61.1% had a bachelor's degree from other medical sciences universities in Iran. The description of the studied variables in terms of the two study groups is presented in Table 1.

Using the instructional designs and developing a lesson plan, instructional content was prepared for 23 epidemiological skills titles. The most crucial goal of each title to learning objectives was to raise students' awareness, attitudes, and performance during the two-hour class. The list of the prepared contents is provided in Table 2. The contents mentioned above were prepared by instructors as instructional interventions in the form of 40 multimedia educational files with a duration of 1129 minutes (18.8 hours) and ten text files as prioritized instructional content about 23 titles of epidemiological skills and provided to students on the LMS platform to be watched at home. In addition to the previously mentioned prepared files, six files containing complementary instructional content in the form of 84-minute videos were downloaded from the Internet and provided to the students. During the implementation of instructional interventions and evaluation of the intervention, the students were asked to prepare and send a video for each topic according to the taught syllabus as their homework after watching the videos uploaded on the system and studying and reviewing the lesson content. Overall, each student prepared 42 multimedia video files of the implemented required skills during the semester and sent them to the instructors. In more than 85% of cases, the students responded on time and sent the above-mentioned assignments promptly. The mentioned files were saved on CDs and kept in the archives of the Center's Epidemiology Laboratory and were accessible. After the development of the lesson plan and its implementation during two academic semesters, the mean ± SD of the scores pre-instructional intervention of teaching epidemiology laboratory was 42.1 ± 8.4 in the intervention group with the FC method and 96 ± 2.1 post-instructional intervention, respectively. The mean ± SD of the scores pre-instructional intervention of teaching epidemiology laboratory in the control group with the direct teaching method during an academic semester was 41.3 ± 3.2, and after direct teaching of the epidemiology laboratory course, it was 77.3 ± 4.7.

Table 3 presents the mean ± SD of the student's learning scores. Based on the comparison results, there was no significant difference ($P = 0.925$) between the intervention group with the online flipped teaching method and the control group with the direct teaching method. However, a statistically significant difference was found between the evaluation scores of the two groups for the implementation of skill performance observation. The skills implemented in the intervention group with the flipped method had higher scores, and the difference was statistically significant ($P = 0.013$).

Based on the results in Table 4, in the measurement and evaluation of the students' epidemiological skills in terms of the group, 54.5 points were added to the scores of the students' epidemiological skill levels post-intervention in the intervention group with the online FC method. This score increase was 36 for the control group with the direct teaching method. The means ± SD of the student's skill scores pre- and post-intervention are reported in Table 4. There was no statistically significant difference between the two groups regarding evaluation scores pre-intervention ($P > 0.05$). A statistically significant difference was observed between the two groups post-intervention ($P < 0.001$). Given the normal distribution and equality of variances, pre-intervention scores of the two groups were compared using an independent t-test, and no significant difference ($P = 0.876$) was found

Table 1. Description of Students Participating in This Study Based on the Educational Program

Variable	Study Group	Means ± Standard Deviations	Minimum-Maximum	*P* Value
Age (y)	Direct teaching	34 ± 4.3	31-39	0.559
	Flipped classroom	34 ± 5.8	26-42	
Bachelor's grade point average	Direct teaching	17.3 ± 1.8	16.3-17.9	0.867
	Flipped classroom	17.1 ± 0.7	16-18.1	

Table 2. Instructional Content Designed for Intervention and Teaching Epidemiological Skills

Row	Name of Skill	Row	Name of Skill
1	Investigation of the disease epidemic in society and interpretation of the findings and the epidemic curve	13	Data cleaning
2	Health data collection and analysis methods	14	Qualitative studies
3	Validity assessment method for data collection instrument	15	GIS mapping of a disease outbreak
4	Reliability assessment method for data collection instrument	16	Principles of disease care in the health system
5	Use of Stata software for data analysis	17	Proposal and research writing in the health system
6	Research result presentation and interpretation method	18	Use of MedCalc software
7	Evaluation of scientific evidence in different studies	19	Types of epidemiologic study designs
8	Systematic review	20	Calculation of health assessment indices and confidence intervals
9	Meta-analysis	21	Calculation of effect size measurement indices and confidence intervals
10	Identification of research errors and ways to control them	22	Correlation and correlation coefficients
11	Methods for sample size determination	23	Regression analyses using software
12	Sampling methods used in epidemiological studies		

Table 3. Means ± Standard Deviations of Learning Scores of MSc Students in Epidemiology

Variable	Study Group	Midterm Exam	Final Exam	*P* Value*
Learning scores	Online flipped classroom	15.75 ± 0.75	19.05 ± 0.05	0.925
	Direct teaching	14.83 + 0.76	19.03 ± 0.3	
Evaluation scores of the implementation of skill performance observation	Online flipped classroom	14.68 ± 0.97	17.53 ± 0.6	0.013
	Direct teaching	13.03 ± 0.50	16.5 ± 0.5	

Note. *Significance value for comparing the final exam scores of the two groups.

Table 4. Comparison of Means ± Standard Deviations of the Students' Skills Scores Pre- and Post-educational Interventions

Research Group		Pre-intervention	Post-intervention	Amount of Change	Significance Value	
					Wilcoxon	Monte-Carlo
Control: Passing the epidemiology laboratory course using the direct teaching method		41.3 ± 3.2	77.3 ± 4.7	36 ± 3	0.109	0.248
Intervention: Passing the epidemiology laboratory course using an online flipped classroom		42.1 ± 8.4	96.6 ± 2.1	54.5 ± 7.7	0.028	0.028
Evaluation of variances	F test value	3.28	3.72	2.98	-	-
	Significance value	0.113	0.095	0.127	-	-
Comparison of two groups	T-test value	0.161	8.77	3.86	-	-
	Significance value	0.876	0.001	0.006	-	-

between the two groups. These scores showed statistically significant differences between the two groups post-intervention. Compared to the direct teaching method, teaching through the FC method significantly increased the students' epidemiological skills. The mean ± SD of the student satisfaction scores was 67.8 ± 16 in the intervention group with the FC method, which increased to 97.6 ± 5.6 post-intervention. The mean ± SD of students' satisfaction scores in the control group with the direct teaching method was 45.3 ± 16, which increased to 87.3 ± 4.5. Table 5 compares the mean ± SD of the student's satisfaction scores pre- and post-intervention.

According to the students' satisfaction evaluation regarding the group, 29.8 points were added to the students' satisfaction scores in the intervention group with the flipped method post-intervention (Table 5). The satisfaction score in this group demonstrated a statistically significant difference in the pre- and post-intervention comparison ($P = 0.03$). This increase was 42 points for the control group with the direct teaching method, which had no statistically significant difference in this group in the pre- and post-comparison ($P = 0.248$). Considering the close approximation to the normal distribution and equality of variances, the pre-intervention scores of the two groups were compared using the independent t-test. No significant difference was found ($P = 0.057$) between the two groups. This comparison was conducted using the Mann-Whitney U test, and no significant difference was observed between the two groups ($P = 0.121$). These scores revealed no statistically significant difference ($P = 0.197$) in the post-intervention comparison between the two groups. Figure 1 depicts epidemiological learning, performance, skills, and students' satisfaction scores pre- and post-educational interventions in each study group. The change in the percentage of scores of the students' epidemiological skills increased by 56% and 46% with

Table 5. Comparison of Means ± Standard Deviations of the Students' Satisfaction Scores Pre- and post-educational Interventions

Research Group		Pre-intervention	Post-intervention	Amount of Change	Significance Value	
					Wilcoxon	Monte-Carlo
Control: Passing the epidemiology laboratory course using the direct teaching method		45.3 ± 5.0	87.3 ± 4.5	42 ± 9.5	0.109	0.248
Intervention: Passing the Epidemiology laboratory course using the online flipped classroom		67.8 ± 16.0	97.6 ± 5.6	29.13 ± 0.8	0.028	0.03
Evaluation of variances	F test value	1.43	2.17	0.752	-	-
	Significance value	0.27	0.184	0.414	-	-
Comparison of two groups	Independent t-test	2.27	-	1.34	-	-
	Significance value	0.057	-	0.220	-	-
	Mann–Whitney Test	1.54	1.5	4	-	-
	Significance value	0.121	0.051	0.197	-	-

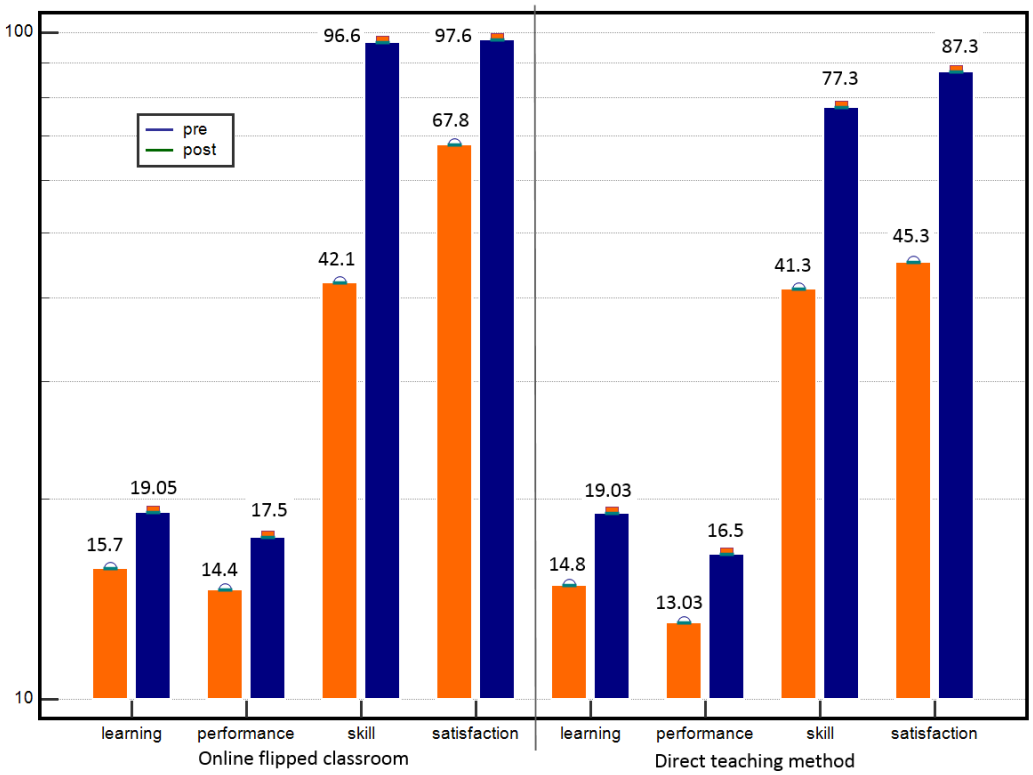

Figure 1. Epidemiological Learning, Performance, Skill, and Students' Satisfaction Scores Pre- and Post-educational Interventions in Each Study Group

the intervention through the FC and direct methods, respectively. The increased scores and the obtained scores were compared with the ratios of the expected scores (Table 6).

Discussion

The teaching method is a set of principles, educational activities, and management methods the teacher uses to achieve teaching-learning goals in his/her classroom. In general, there are four teaching methods (i.e., direct transfer-based, interaction-based, problem-based, and individual-based teaching methods). Teaching theories can be organized into four categories based on two major parameters, namely, a teacher-centered approach versus a student-centered approach and high-tech material use versus low-tech material use. In this study, the direct teaching or traditional lecturing method of didactic PowerPoint presentations and activities, such as multiple-choice questions and exercises, was used to complete at home after the class. In addition, the instructional design, implementation, and evaluation of epidemiological skill courses were conducted using the electronic FC method for MSc students in epidemiology at Shahrekord University of Medical Sciences in Iran.

Moreover, the online FC method was compared with the instructor-based direct teaching method, and the results confirmed that the epidemiological skills of students participating in the online FC increased significantly for the ESL course compared to the direct teaching method. However, their satisfaction with this teaching method remained statistically different from the direct method.

A general comparison of the findings of the present

Table 6. Change Percentage and Scores Obtained Pre- and Post-intervention in Terms of Questionnaire and Teaching Method of Epidemiological Skills Laboratory in MSc Students of Shahrekord University of Medical Sciences

Questionnaire	Maximum Score Expected to Obtain	Direct Classroom (Percentage of Acquisition)		Flipped Classroom (Percentage of Acquisition)		Percentage of Score Change	
		Pre	Post	Pre	Post	Direct Teaching	Flipped Teaching
Epidemiological skills	115	35.9 (31.2)	67.2 (58.4)	36.6 (31.8)	84 (73)	46.5%	56.4%
Students satisfaction	120	41.1 (34.2)	79.3 (66)	61.6 (51.3)	88.7 (73.9)	48.1%	30.5%

study with those of previous research, including the one conducted in Lorestan [14], revealed that students learning with the FC method were similar to and even better than those learning with the direct teaching method. Additionally, the students' satisfaction with this method was much higher than that of the direct methods, which is consistent with the results of the above-mentioned study.

The methodology used in our study is similar to the one employed in studies conducted in 2015-2016 (i.e., the FC and direct teaching methods) to present the principles of the epidemiology course; however, the comparison of our findings was expected to be more consistent with that study. The above-mentioned study reported no statistically significant differences in the examination scores of students' assessments using the direct teaching and FC methods. The findings of this study also demonstrated that the students' satisfaction was increased with the FC, and more flexibility and learning opportunities were provided at home,[15] which contradicts our findings.

In line with our study, another study conducted in 2017 in South Korea presented five topics in the epidemiology course for third-year medical students at the College of Medicine Korea University through the FC method. The researchers found no significant difference between test scores before and after the course.[16] The inconsistency of our study results with those of the study by Sohn et al can be justified by how the population studied in South Korea differed from ours. In their study, the intervention was implemented for medical students. In contrast, in our study, the intervention was implemented on the postgraduate students in epidemiology. These students engaged more sensitively with the learning process due to the topics' specificity. Our findings conform to those of a systematic review and meta-analysis published in 2020. This study evaluated the application of the FC method for nursing students' theoretical learning in China. The FC method created a flux of interest in nursing education in China. The researchers of this study compared the FC and lecture-based learning (LBL) and found that no systematic review has comprehensively compared theoretical scores as an outcome affected by FC compared to the LBL state. The theoretical knowledge scores of the FC method were significantly affected compared to the direct classroom.

Moreover, 23 studies reported skill scores showing a significant difference between the FC and LBL modes. This meta-analysis revealed that the FC method has significantly improved the theoretical scores of Chinese nursing students compared to the LBL method. Nevertheless, this research's heterogeneity and publication bias problems require the modification of high-quality future studies.[17-19]

Another study evaluated teaching immunology courses using the FC method from the perspective of the students of Shiraz University of Medical Sciences.[20] The findings of our study are in agreement with those of the study mentioned above, indicating that in different components, the scientific richness of the provided content, classroom management by the instructor, the opportunity for posing questions by the learner, and group work of the students gained the highest desirability. However, items such as explaining complex and challenging concepts, providing equal opportunities for learners in class, providing the required opportunity for offering written and verbal feedback to students, and preparing students in advance had the lowest desirability.

Performing an instructional needs analysis pre-intervention, choosing interventions based on the prioritization of the instructional needs analysis, and designing instructional interventions were among the strengths of this study. Controlling confounding variables in comparison with the effectiveness of the FC using two asynchronous control groups and comparing the design in the form of pre- and post-interventions were other strengths of the study. However, the small sample size was one of the limitations of our research, which is inherent to postgraduate students. All students were included in the study by census, and the role of chance was controlled as much as possible in the analysis.

Conclusion

Under the COVID-19 epidemic, mainly the virtualization of students' education and easy access to virtual education systems to convey instructional content, it is a favorable opportunity to employ the electronic FC method to teach students. Using the online FC method in teaching and learning is a new opportunity. It facilitates the learning conditions and promotes practical skills in postgraduate students. In this study, the students' epidemiological skill scores showed a statistically significant increase in the intervention group with the FC method compared to pre- and post-instructional interventions in each group. However, the epidemiological skill scores demonstrated no statistically significant increase in the direct teaching method group. The findings of this study revealed that the online flipped teaching method had a statistically significant effect on increasing the students' epidemiological skills compared to the direct teaching method. The students' satisfaction scores in epidemiological skills indicated no statistically significant increase in the intervention

group with the FC method compared to pre- and post-instructional interventions in each group. However, the students' satisfaction scores statistically and significantly increased in the direct teaching method group.

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Competing Interests

The authors declare that there is no conflict of interests.

Ethical Approval

Ethical considerations in this study included obtaining permission from the Ethics Committee of Smart University of Medical Sciences, Tehran, Iran (Ethical code: IR.VUMS.REC.1399.005) and obtaining written consent from the participants to participate in the study.

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References

1. Frérot M, Lefebvre A, Aho S, Callier P, Astruc K, Aho Glélé LS. What is epidemiology? Changing definitions of epidemiology 1978-2017. PLoS One. 2018;13(12):e0208442. doi: 10.1371/journal.pone.0208442.
2. Anderson W. The history in epidemiology. Int J Epidemiol. 2019;48(3):672-4. doi: 10.1093/ije/dyy247.
3. Olshan AF, Diez Roux AV, Hatch M, Klebanoff MA. Epidemiology: back to the future. Am J Epidemiol. 2019;188(5):814-7. doi: 10.1093/aje/kwz045.
4. Fox MP, Murray EJ, Lesko CR, Sealy-Jefferson S. On the need to revitalize descriptive epidemiology. Am J Epidemiol. 2022;191(7):1174-9. doi: 10.1093/aje/kwac056.
5. D'Agostino EM, Hlaing WM, Stark JH. Teaching on the continuum: epidemiology education from high school through graduate school. Am J Epidemiol. 2019;188(6):979-86. doi: 10.1093/aje/kwz059.
6. Purtle J, Nelson KL, Counts NZ, Yudell M. Population-based approaches to mental health: history, strategies, and evidence. Annu Rev Public Health. 2020;41:201-21. doi: 10.1146/annurev-publhealth-040119-094247.
7. Linling Z, Abdullah R. The impact of COVID-19 pandemic on flipped classroom for EFL courses: a systematic literature review. Sage Open. 2023;13(1):21582440221148149. doi: 10.1177/21582440221148149.
8. Erbil DG. A review of flipped classroom and cooperative learning method within the context of Vygotsky theory. Front Psychol. 2020;11:1157. doi: 10.3389/fpsyg.2020.01157.
9. Arora M, Waikhom P, Azad S, Thakker V, Azad RK, Srivastava RK. Impact of COVID-19 on postgraduate medical education: cross sectional survey from an Indian medical college. J Educ Health Promot. 2022;11:294. doi: 10.4103/jehp.jehp_1698_21.
10. Özcan C. Flipped classroom in restorative dentistry: a first test influenced by the COVID-19 pandemic. Oral Health Prev Dent. 2022;20:331-8. doi: 10.3290/j.ohpd.b3276187.
11. 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(1):835-42. doi: 10.2147/amep.s294980.
12. Khodaei S, Hasanvand S, Gholami M, Mokhayeri Y, Amini M. The effect of the online flipped classroom on self-directed learning readiness and metacognitive awareness in nursing students during the COVID-19 pandemic. BMC Nurs. 2022;21(1):22. doi: 10.1186/s12912-022-00804-6.
13. Huang TX, Kuo HH, Lo TS, Liang CC, Lin YH, Chou HH. Combing pre-workshop, web-based learning and hands-on workshop as a flipped classroom clinical skill training model during the COVID-19 pandemic. Taiwan J Obstet Gynecol. 2022;61(5):755-60. doi: 10.1016/j.tjog.2021.10.008.
14. Li BZ, Cao NW, Ren CX, Chu XJ, Zhou HY, Guo B. Flipped classroom improves nursing students' theoretical learning in China: a meta-analysis. PLoS One. 2020;15(8):e0237926. doi: 10.1371/journal.pone.0237926.
15. Shiau S, Kahn LG, Platt J, Li C, Guzman JT, Kornhauser ZG, et al. Evaluation of a flipped classroom approach to learning introductory epidemiology. BMC Med Educ. 2018;18(1):63. doi: 10.1186/s12909-018-1150-1.
16. Sohn S, Lee YM, Jung J, Cha ES, Chun BC. The flipped classroom model for an undergraduate epidemiology course. Korean J Med Educ. 2019;31(2):103-13. doi: 10.3946/kjme.2019.122.
17. Yom KH, Diel RJ, Kemp PS. A comparison of the flipped classroom model for medical student education in ophthalmology before and during the COVID-19 pandemic. J Acad Ophthalmol (2017). 2021;13(2):e228-33. doi: 10.1055/s-0041-1740397.
18. Du J, Chen X, Wang T, Zhao J, Li K. The effectiveness of the fully online flipped classroom for nursing undergraduates during the COVID-19: historical control study. Nurs Open. 2023;10(8):5766-76. doi: 10.1002/nop2.1757.
19. de Jong N, van Rosmalen P, Brancaccio MT, Bleijlevens MH, Verbeek H, Peeters IG. Flipped classroom formats in a problem-based learning course: experiences of first-year bachelor European public health students. Public Health Rev. 2022;43:1604795. doi: 10.3389/phrs.2022.1604795.
20. Mohebbi Z, Mortezaei-Haftador A, Mehrabi M. Synchronous online lecturing or blended flipped classroom with jigsaw: an educational intervention during the COVID-19 pandemic. BMC Med Educ. 2022;22(1):845. doi: 10.1186/s12909-022-03915-5.