Supplementary materials

1. Table of specification of the exam

	Asynchronous class	Synchronous class
Number of examination items (n)	**20**	**20**
All teaching sessions		
An introduction to nuclear medicine	1	1
Dual energy x-ray absorptiometry	1	2
The thyroid gland	3	3
The skeletal system	2	2
The lymphovascular system	2	2
The gastrointestinal system	2	1
The urinary system	2	1
The hepatobiliary system	1	2
Nuclear cardiology	2	3
Nuclear neurology	2	1
Nuclear oncology	2	2
Number of examination items (n)	**10**	**10**
Teaching sessions taught by the same instructors		
An introduction to nuclear medicine	1	1
The thyroid gland	3	3
The skeletal system	2	2
The lymphovascular system	2	2
Nuclear oncology	2	2

2. Item analyses

In the following table, we provide item analyses for the examination items used in both the asynchronous and synchronous classes. The table displays topics corresponding to each examination item as well as the learning outcomes of each question. Difficulty levels indicate the level of difficulty for each examination item, as determined by a committee comprising two board-certified nuclear medicine physicians and two physicians from other specialties. These items were classified into five difficulty levels, with 5 representing the most difficult and 1 representing the easiest for medical students. This process is routinely conducted as part of our examination quality assurance. The percent corrected values (PCV) represent the fractions of students who answered each question correctly. Therefore, a PCV of 1 indicates that all students answered these questions correctly.

Exam items	Topics	Learning outcomes	Difficulty levels	PCV	Standard deviation	Discrimination indices
Asynchronous class						
1	Introduction to nuclear medicine	Method and procedure	2	0.93	0.26	0.18
2	Thyroid	Indication	3	0.83	0.38	0.27
3	Thyroid	Method and procedure	3	0.96	0.19	0.07
4	Thyroid	Indication	3	0.92	0.28	0.15
5	Skeletal system	Interpretation	3	0.86	0.35	0.21
6	Skeletal system	Indication	3	0.68	0.47	0.50
7	Nuclear oncology	Indication	3	0.77	0.42	0.46
8	Nuclear oncology	Method and procedure	3	0.90	0.30	0.18
9	Lymphovascular system	Indication	4	0.25	0.43	0.31
10	Lymphovascular system	Method and procedure	3	0.73	0.45	0.40
11	Gastrointestinal system	Interpretation	3	0.87	0.34	0.34
12	Gastrointestinal system	Indication	3	1.00	0.06	0.01
13	Nephrology	Indication	3	0.65	0.48	0.25
14	Nephrology	Indication	3	0.98	0.13	0.05
15	Dual energy x-ray absorptiometry	Method and procedure	3	0.77	0.42	0.34
16	Cardiac system	Indication	3	0.93	0.26	0.18
17	Cardiac system	Method and procedure	4	0.95	0.23	0.12
18	Nuclear neurology	Interpretation	4	0.47	0.50	0.45
19	Nuclear neurology	Indication	4	0.51	0.50	0.66
20	Hepatobiliary system	Indication	3	0.49	0.50	0.04
Synchronous class						
1	Introduction to nuclear medicine	Method and procedure	3	0.94	0.24	0.11
2	Thyroid	Indication	4	0.94	0.23	0.06
3	Thyroid	Method and procedure	4	0.90	0.30	0.16
4	Thyroid	Common pathology	4	0.71	0.46	0.32
5	Skeletal system	Indication	3	0.91	0.29	0.12
6	Skeletal system	Interpretation	4	0.79	0.41	0.38
7	Nuclear oncology	Indication	4	0.60	0.49	0.45
8	Nuclear oncology	Method and procedure	4	0.93	0.26	0.09
9	Lymphovascular system	Indication	4	0.98	0.15	0.06
10	Lymphovascular system	Method and procedure	3	0.85	0.35	0.20
11	Gastrointestinal system	Indication	4	0.41	0.49	0.31
12	Nephrology	Indication	4	0.27	0.44	0.24
13	Dual energy x-ray absorptiometry	Interpretation	3	0.72	0.45	0.30
14	Dual energy x-ray absorptiometry	Method and procedure	4	0.92	0.27	0.22
15	Cardiac system	Indication	3	1.00	0.00	0.00
16	Cardiac system	Indication	3	0.97	0.16	0.09
17	Cardiac system	Common pathology	3	0.99	0.12	0.03
18	Nuclear neurology	Indication	4	0.22	0.42	0.14
19	Hepatobiliary system	Indication	3	0.48	0.50	0.42
20	Hepatobiliary system	Indication	3	0.84	0.36	0.24

3. GREET 2015 Checklist

BRIEF NAME: Synchronous versus Asynchronous Online Nuclear Medicine Learning for Medical Students.
1. INTERVENTION: Asynchronous group: Third year medical students participate in online asynchronous learning of nuclear medicine course using pre-recorded lectures. Synchronous group: Third year medical students participate in online synchronous learning of nuclear medicine course using online teleconferencing software.
WHY - this educational process
2. THEORY: Asynchronous online learning may be able to facilitate study of students who are able to study at their own pace. There have been some studies comparing asynchronous online learning to synchronous in-person learning, but not many have compared asynchronous online learning to synchronous online learning. 3. LEARNING OBJECTIVES: The learning objective for both groups are their knowledge in nuclear medicine, which was assessed by single-best answer multiple choice question exam. 4. EBP CONTENT: Some of the pre-existing studies suggested that synchronous learning resulted in better academic performance among medical students. However, there have also been other studies that suggested learners in asynchronous environments could obtain comparable knowledge, probably benefiting from the self-paced nature of the courses.
WHAT
5. MATERIALS: Asynchronous group: Pre-recorded videos, handouts, anonymous instant messaging chatrooms, live Q&A sessions. Synchronous group: Teleconferencing software (Zoom), Audience response system (Kahoot!), handouts, emails. 6. EDUCATIONAL STRATEGIES: The strategies in both groups are lectures modules. 7. INCENTIVES: No incentives for the participation.
WHO PROVIDED
8. INSTRUCTORS: All instructors involved in this learning intervention are board-certified nuclear medicine physician who have certified by the Thai Medical Council.
HOW
9. DELIVERY: The learning delivery was done online. The intervention was provided to each cohort of students as large group lectures. The ratio of instructor to students was 8 instructors over 241 students in the asynchronous cohort, and 7 instructors over 268 students in the synchronous cohort.
WHERE
10. ENVIRONMENT: The learning occurred in online environment
WHEN and HOW MUCH
11. SCHEDULE: There were 11 teaching sessions and each session were 45-60 minutes long.

12. Describe the amount of time learners spent in face-to-face contact with instructors and any designated time spent in self-directed learning activities:
There was no allocated time for face-to-face contact with instructor because all activities were performed online.

PLANNED CHANGES

13. Did the educational intervention require specific adaptation for the learners? If yes, please describe the adaptations made for the learner(s) or group(s):
Yes. We provide an anonymous instant messaging chat room for the students in the asynchronous online classes, and we provide supported to the synchronous online class via emails.

UNPLANNED CHANGES

14. Was the educational intervention modified **during** the course of the study? If yes, describe the changes (what, why, when, and how):
No, there were no changes of intervention during the course of the study.

HOW WELL

15. ATTENDANCE:
We did not collect the data on the attendance of students in each class.

16. Describe any processes used to determine whether the materials (item 5) and the educational strategies (item 6) used in the educational intervention were delivered as originally planned:
Because the learning management system we used did not possess the ability to keep record logs, we cannot determine whether the material was assessed, which is a limitation of this study.

17. Describe the extent to which the number of sessions, their frequency, timing and duration for the educational intervention was delivered as scheduled (item 11):
All educational interventions were delivery as scheduled.