

## The International Electroencephalography and Epilepsy Course at UH Cleveland Medical Center: Pre- and Post-course performance

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### **Introduction:**

The first Electroencephalography (EEG)/Epilepsy course was offered in Cleveland, Ohio in 1979, organized by professor Hans Lüders. His vision was to teach systematic and critical analysis of electroencephalography and impart basic working knowledge of epilepsy. The course participants are assumed to have no prior knowledge of EEG or epilepsy. Thus, the course curriculum is structured and paced to meet the desired competency as determined by the organizing committee. The course is 2 months-long, free of charge, and offered twice a year at the University Hospitals Cleveland Medical Center (UHCMC). Excluding the time spent outside of class for completion of daily homework assignments and 3-5 weekly reading assignments, students spend ~280 hours in classroom setting. The average class size is between 25 and 30 (Pre-pandemic), composed of individuals from around the world, as well as in-house neurology residents, epilepsy/clinical neurophysiology fellows, neurocritical care fellows, epilepsy research scholars, and newly-hired EEG technologists at UHCMC. The course content has evolved over the years to reflect advancement of the field of epilepsy. All core faculty members of the course have previously taken the course and go through continuing education sessions twice a week (1hour/session) in clinical neurophysiology and seizure semiology throughout the year. Each week of the course is assigned to a core faculty member. (Figure 1) Course participants gain much knowledge during the course as shown by their improved performance on homework assignments, final exams, and post-course feedback. This study aimed to objectively evaluate effectiveness of the course using before and after- course exams.

## **Methods:**

Details of the course curriculum was presented at the American Epilepsy Society Annual Meeting 2017 (1) and published recently (2).

Thirteen students enrolled in the course and completed the curriculum: 5 Post Graduate Year (PGY3) UH CMC neurology residents with no prior knowledge of EEG/Epilepsy, 2 third-year clinical neurophysiology residents from Spain, 1 child neurologist from Turkey with less than 1 week of post-graduate clinical practice, 1 fifth-year neurology resident from Poland, 4 international medical doctors applying to neurology residency with no prior history of medical practice. One student (#8) did not take the pre-course exam due to being quarantined for a 1week after her international travel during pandemic. Therefore, she was excluded from data analysis. All students completed the course.

During 2.5 hours of orientation on the first day of the course, the following details were reviewed: 1. Course curriculum 2. The purpose of the “EEG unknowns” 3. How to answer the “EEG unknowns” as part of daily homework assignment. 4. Six different montages used to answer the “EEG unknowns”. Then, a *pre-course* exam was given consisting of 5 “EEG unknown” (EEGUKN) (8 points each, 40 points total) (see below) and 30 multiple-choice questions (MCQs) for a total of 70 points on the pre-course exam. After 2 months, the same pre-course exam was used for *post-course* exam. *No participant received feedback on their pre-test, and no one was allowed to keep any of the pre-test materials.* The students were previously unaware of the pre-course exam and the fact that the questions were extracted from the final exam. The final exam consisted of the same pre-course exam questions combined with an additional 5 EEGUKN (8 points each, 40 points total) and an additional 37 MCQs for a total of 147 points on the posttest. One hour was allotted for the pre-course exam, and two and a half hours for the final exam. Background of each student and his/her performance on pre-and post-course exams were entered in Microsoft Excel Spread Sheet®.

### “EEG unknown”

A 15-second page of a sample patient’s EEG (without demographic data) is shown without the montage on paper. (Figure 2) The montage is one of 6 runs (Figure): Run 1: “double banana” bipolar, Run 2: Reference to A1 and A2, Run 3: alternating bipolar, Run 4: alternating reference to CZ, Run 5: Transvers bipolar, Run 6: bipolar with sphenoid electrodes. (Figure 3) A montage sheet is included with all exams for reference. This exercise requires knowledge of neurophysiology of normal and abnormal EEG features, including localization skills, EEG characteristics in different state of consciousness, characteristics of EEG waveforms in relation to age, and thorough understanding of the general gestalt of each montage. Students are expected to figure out the age, level of consciousness, montage, presence of artifacts/normal variants, EEG classification, and finally most likely clinical correlation. (Figure 4).

### Multiple Choice Questions

The multiple choice questions relate to topics in clinical epileptology covered in the course including: epilepsy in adults and children, seizure semiology, epilepsy surgery, neuropathology in epilepsy, neuroimaging in epilepsy, sleep, intraoperative monitoring, neuropsychology, neuroimmunology in epilepsy, and antiepileptic drugs.

## Results

### Overall class performance

All analyses were conducted using two-tailed paired t-tests. All tests were two-tailed and  $p < .05$  considered significant. Individual raw scores are shown in Table 1.

Average pre-test score was  $31 \pm 11\%$  (range: 13-47%). Average post-test score was  $66 \pm 14\%$  (range: 38-89%). Improvement from pre-test to post-test was statistically significant,  $p < .001$ . The mean difference in exam scores was  $35 \pm 9\%$  (range: 25%-50%). Average percentage change was 112.9%, indicating the average student improved by 112.9%. (Figure 5, 6)

Scores for EEG unknowns were  $8.17 \pm 5.61$  at pretest (range: 0.00-16.00) and  $22.71 \pm 7.23$  at post-test (range: 13.50-38.00), a statistically significant difference,  $p < .001$ . The mean difference in EEG unknown scores was  $19.54 \pm 6.12$  (range: 9.50-32.00). Average percentage change was 239.17%, indicating the average student improved by 239.17%. (Figure 6)

Scores for MCQ were  $13.58 \pm 3.90$  at pretest (range: 8.00-22.00) and  $19.54 \pm 6.12$  at post-test (range: 13.00-24.00), a statistically significant difference,  $p < .001$ . The mean difference in MCQ scores was  $4.92 \pm 3.03$  (range: 0.00-9.00). Average percentage change was 36.23%, indicating the average student improved by 36.23%. (Figure 6)

### UH CMC Neurology residents

Average pre-test score was  $36 \pm 7\%$  (range: 28%-47%). Average post-test score was  $67 \pm 4\%$  (range: 62%-74%); this improvement was statistically significant,  $p < .001$ . The mean difference in exam scores was  $31 \pm 6\%$  (range: 26%-41%). Average percentage change was 86.11%, indicating the average student improved by 86.11%. (Figure 7)

Scores for EEG unknowns were  $9.61 \pm 4.55$  at pretest (range: 4.54-15.50) and  $26.80 \pm 1.36$  at post-test (range: 25.00-28.50); this improvement was statistically significant,  $p = .002$ . The mean difference in EEG unknown scores was  $17.19 \pm 5.31$  (range: 9.50-23.21). Average percentage change was 178.88%, indicating the average student improved by 178.88%.

Scores for MCQ were  $15.60 \pm 4.39$  at pretest (range: 11.00-22.00) and  $20.00 \pm 2.55$  at posttest (range: 17.00-23.00); this improvement was not statistically significant,  $p = .071$ . The mean difference in MCQ scores was  $4.40 \pm 4.04$  (range: 0.00-9.00). Average percentage change was 28.21%, indicating the average student improved by 28.21%.

## Conclusion

This study objectively demonstrated effectiveness of the EEG/Epilepsy Course curriculum at UH CMC.

Table 1

Individual performance on pre- and Post-Course exam.

Student #	Pre-course exam			Overall Score-Pre	Post-course exam			Overall Score-Post
	5 Unknown	30 MCQ	Overall Score-Pre		5 Unknown	30 MCQ	Overall Score-Post	
1	15.5	16	31.5	45%	38	24	62	89%
2	16	12	28.0	40%	36	18	54	77%
3	6	15	21.0	30%	33	21	54	77%
4	3.5	14	17.5	25%	35.5	17	53	75%
5	11	22	33.0	47%	28.5	23	52	74%
6	5.5	14	19.5	28%	26.25	22	48	69%
7	4.54	18	22.5	32%	27.75	18	46	65%
8	0	0	0.0	0%	27.5	18	46	65%
9	15.5	11	26.5	38%	25	20	45	64%
10	11.5	13	24.5	35%	26.5	17	44	62%
11	7.5	11	18.5	26%	24	13	37	53%
12	1.5	8	9.5	14%	18.5	16	35	49%
13	0	9	9.0	13%	13.5	13	27	38%

Figure 6

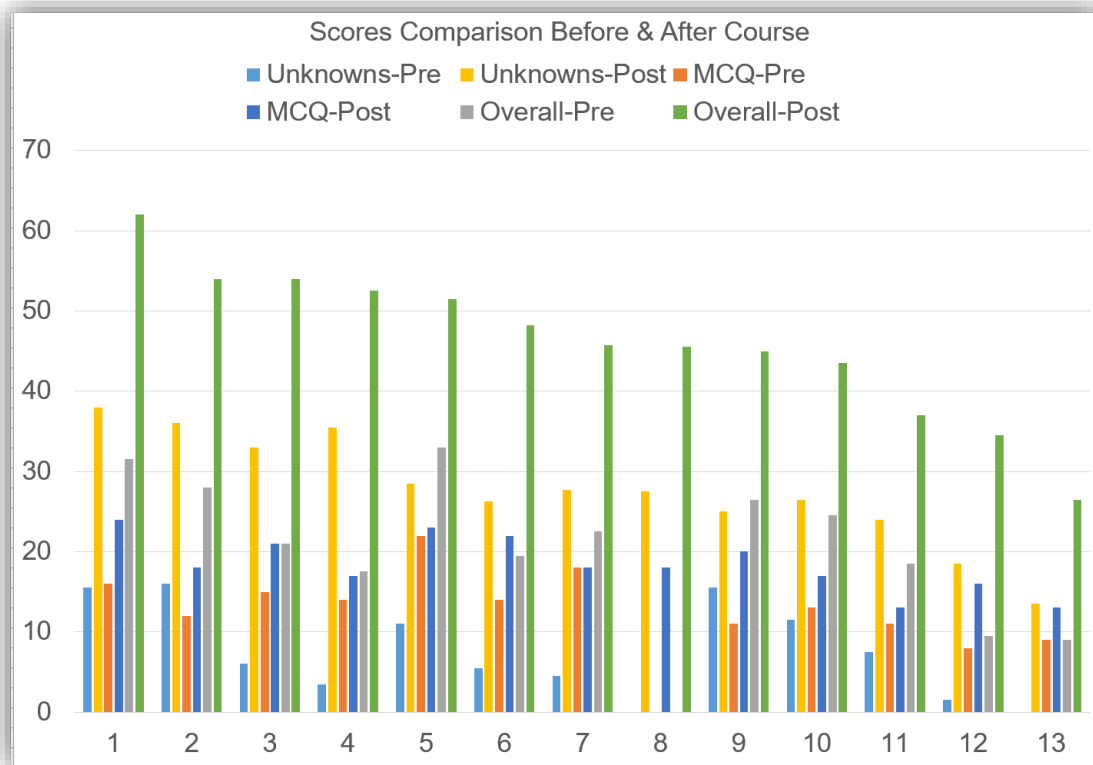


Figure 5

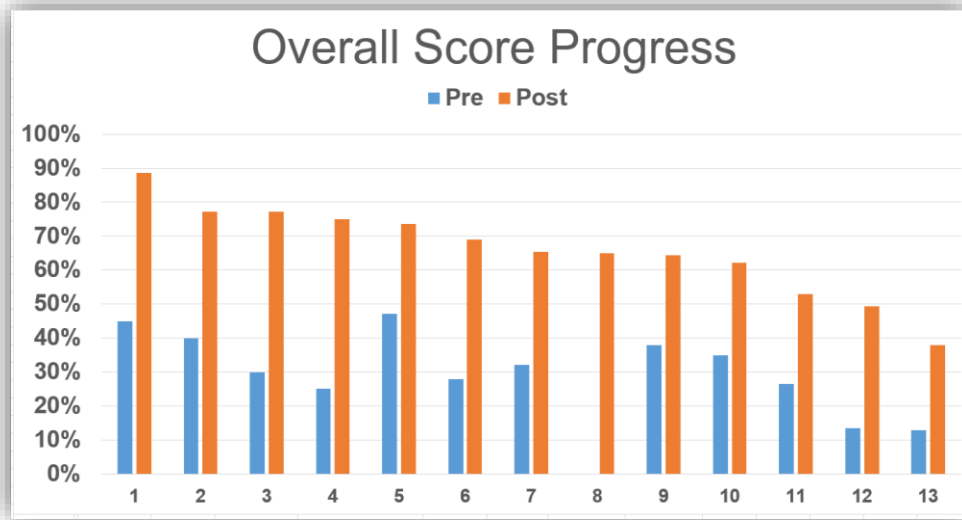


Figure 7

Overall performance comparing UHCMC neurology resident with international participants

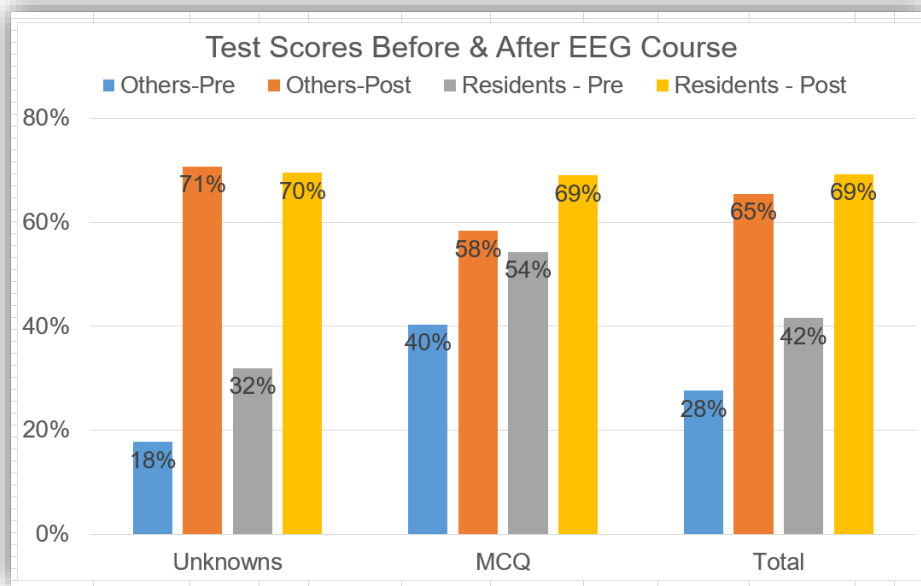


Figure 3

Six montages used a reference to answer EEG unknowns

Channel	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
1	Fp1 - F7	Fp1 - A1	Fp1 - F7	Fp1 - Cz	F7 - F3	Fp1 - F7
2	F7 - T7	F7 - A1	Fp2 - F8	Fp2 - Cz	F3 - Fz	F7 - FT9
3	T7 - P7	T7 - A1	F7 - T7	F7 - Cz	Fz - F4	FT9 - T7
4	P7 - O1	P7 - A1	F8 - T8	F8 - Cz	F4 - F8	T7 - P7
5	Fp2 - F8	Fp2 - A2	T7 - P7	T7 - Cz	A1 - T7	P7 - O1
6	F8 - T8	F8 - A2	T8 - P8	T8 - Cz	T7 - C3	Fp2 - F8
7	T8 - P8	T8 - A2	P7-O1	P7 - Cz	C3 - Cz	F8 - FT10
8	P8 - O2	P8 - A2	P8 - O2	P8 - Cz	Cz - C4	FT10 - T8
9	Fp1 - F3	F3 - A1	FP1 - F3	F3 - Cz	C4 - T8	T8 - P8
10	F3 - C3	C3 - A1	FP2 - F4	F4 - Cz	T8 - A2	P8 - O2
11	C3 - P3	P3 - A1	F3 - C3	C3 - Cz	P7 - P3	FT9 - FT10
12	P3 - O1	O1 - A1	F4 - C4	C4 - Cz	P3 - Pz	A1 - A2
13	Fp2 - F4	F4 - A2	C3 - P3	P3 - Cz	Pz - P4	Fp1 - F3
14	F4 - C4	C4 - A2	C4 - P4	P4 - Cz	P4 - P8	F3 - C3
15	C4 - P4	P4 - A2	P3 - O1	O1 - Cz	Fp1 - A1	C3 - P3
16	P4 - O2	O2 - A2	P4 - O2	O2 - Cz	Fp2 - A2	Fp2 - F4
17	Fz - Cz	Fz - A2	Fz - Cz	FT9 - Cz	O1 - A1	F4 - C4
18	Cz - Pz	Cz - A2	Cz - Pz	FT10 - Cz	O2 - A2	C4 - P4
19	EKG	Pz - A2	EKG	A1 - Cz	EKG	EKG
20		EKG		A2 - Cz		
21				EKG		

Figure 4

Sample of completed answer sheet of "EEG unknown"

(67.25)

RESIDENT'S NAME \_\_\_\_\_

DATE TURNED IN \_\_\_\_\_

SIGNATURE OF PHYSICIAN TEACHING \_\_\_\_\_

Record #	Age	Level of Consciousness	Montage sec *	Artifacts Normal Variants	EEG Classification	Clinical Interpretation
	12-18	Drowsy 1/12	R5	60Hz artifact Eye artifact	Abnormal III: Spike left frontal (F3, C3 P3)	BFEDCh 1/12
	Adult 18-60	Awake	R2	Eng artifact (Fp2) Eye artifact PDR 11 Hz	Abnormal III: spike-wave generalized (max F4)	Generalized epilepsy
	1-3	Sleep	R5	Sleep architecture (spindles, synchronous)	Normal	Normal
	Adult 18-60	Awake	R4	PDR 9 Hz Eng artifact Eye artifact	Abnormal III: seizure pattern-mono- phic theta range activity increasing amplitude (5 Hz); F7, T8, F8)	Right temporal (focal) epileptogenicity
	18-60	Awake	R1	Eng artifact Eye artifact PDR 8 Hz	Abnormal II: Continuous slow right hemisphere (temporal more prominent)	Dysfunction (or structural lesion) on right hemisphere

7

8

7.5

8

7.5

AGE GROUPS: 0-1, 1-3, 3-7, 7-12, 12-18, 18-60, over 60

LEVELS OF CONSCIOUSNESS: Awake, Drowsy, Sleep II-IV, REM Sleep, Lethargy, Stupor, Coma

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Figure 1

Sample of a weekly schedule

<b>*Week 3 (Dr. Lüders)</b>				
<b>Monday</b>	<b>Tuesday</b>	<b>Wednesday</b>	<b>Thursday</b>	<b>Friday</b>
8:00 – 9:15 <b>Frohring Auditorium</b> <b>School of Medicine</b> <b>Epilepsy Grand Rounds</b>  <b>Topic: TBA</b>	8:00 – 9:15 <b>Hanna House 537</b> <b>Fellow EEG Conference</b>  Dr. Hans Lüders	8:30 – 9:15 <b>Bolwell 5198-5199</b> <b>Case Study</b>  Dr. Hans Lüders	8:00 – 9:15 <b>Hanna House 537</b> <b>Fellow Clinical</b> <b>Epilepsy Conf</b>  Dr. Hans Lüders	8:00 – 9:15 <b>Kulas Auditorium</b> <b>Neurology Grand Round</b>  <b>Topic: TBA</b>
9:30 – 11:00 <b>Bolwell 5198-5199</b> Dr. Hans Lüders  <b>General Epileptology</b> <b>Principles</b>	9:30 – 11:00 <b>Bolwell 5198-5199</b> Dr. Hans Lüders  <b>Classification Paroxysmal</b> <b>Events</b> <b>Epileptic Auras</b>	9:15 – 11:00 <b>Bolwell 5198-5199</b> Dr. Hans Lüders  <b>Dialectic Seizures</b> <b>Automotor Seizures</b> <b>Simple Motor Seizures</b>	9:30 – 11:00 <b>Bolwell 5198-5199</b> Dr. Hans Lüders  <b>Complex Motor Seizures</b> <b>Special Seizures</b> <b>Somatotopic Modifiers</b>	9:30 – 11:00 <b>Bolwell 5198-5199</b> Dr. Hans Lüders  <b>Lateralizing Signs</b>
11:00 – 12:00 <b>EEG Discussion</b> Dr. Lüders	11:00 – 12:00 <b>EEG Discussion</b> Dr. Lüders	11:00 – 12:00 <b>EEG Discussion</b> Dr. Lüders	11:00 – 12:00 <b>EEG Discussion</b> Dr. Lüders	11:00 – 12:00 <b>EEG Discussion</b> Dr. Lüders
1:30 – 2:30 <b>Bolwell 5198-5199</b>  <b>EEG Reading</b> Dr. Lüders	1:30 – 2:30 <b>Bolwell 5198-5199</b>  <b>EEG Reading</b> Dr. Lüders	1:30 – 2:30 <b>Bolwell 5198-5199</b>  <b>EEG Reading</b> Dr. Lüders	2:30 – 3:30 <b>Hanna House 537</b> <b>Epilepsy Case Conference</b>	1:30 – 2:30 <b>Bolwell 5198-5199</b>  <b>EEG Reading</b> Dr. Lüders

Figure 2

A sample “unknown EEG” A student is expected answer the following questions: Age, Level of consciousness, Montage, Artifacts (if any), EEG classification, and Impression.

- Age: 3 years old
- Level of consciousness: awake
- Run 5
- Artifacts: muscle artifact, eye movement artifacts
- Abnormal III
  - Spike-and-slow waves, generalized



- Clinical impression:
  - Generalized epilepsy

