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| **Reference (Author, year)** | **Study Design** | **Educational Innovation/Intervention** | **Kirkpatrick Level of Evaluation**  | **Neurological Topic** | **Participants, # of participants** | **Comparison groups** | **Full Text/Abstract** | **Journal** | **Outcomes/Evaluation** | **Results** | **Quality/Covidence #/Title** |
| Schaeffer, et al. (2020)   | Investigational, interventional study   | eLearning  | 2 | Clinical Neurology, Movement disorders   | 117 neurology residents   | Intervention v. control   | Full Text   | *Movement disorders*  | All groups completed pre-, post-, and delayed post-tests (10 questions each). Intervention residents completed modules between pre- and post-tests, and also completed a survey about the process.  | 86/117 residents in the intervention group completed at least one module and 74 completed >/= 5/10 modules. Mean pre-test scores were not significantly different between the intervention and control groups (6.3 vs. 6.5, p=0.47) but the intervention group had significantly higher scores on post- (8.0 vs. 7.1, p=0.02) and delayed post-tests (7.9 vs. 6.9, p=0.02). In the survey, residents indicated that they liked having a framework for movement disorders, appreciated the interactivity, and wanted more modules.  | Good/#5876/ Implementation of an online, interactive curriculum in movement disorders at nine neurology residency programs.  |
| Sajid, et al. (2020)  | Experimental, investigational study   | Flipped classroom   | 2 | Clinical Neurology   | MBBS students   | flipped classroom group vs traditional lecture-based   | Full Text   | *Cureus*  | development and administration of a flipped classroom with one group of students receiving the flipped classroom (FG) and the other group with the traditional lecture-based teaching (LG). We compared the pre-university enrolment Cumulative Grade Point Average (CGPA), preceding progress test results and previous semester performance for the two groups,  | Since the FG had received the video lecture while the LG had not, there was a clear statistical difference between the groups with FG showing better performance in pre-test scores. The post-test performances were marginally not statistically different between FG and LG groups.  | Good/#6123/ Comparative Analysis of Effectiveness Between Flipped Classroom and Lecture-Based Classroom in Undergraduate Medical Education at Alfaisal University.  |
| Alvarez-Sanchez, et al. (2021)   | Quasi experimental study   | Simulation   | 2 | Clinical Neurology   | 34 2nd year medical students   | No comparison group   | Full Text   | *Education Med.*  | All participants were evaluated before and after the IEBS using the basic clinical skills in neurology rubric (HCBN) that considers 9 aspects of neurological examination.  | Using the McNemar test, the difference in the CCEN between the Pre-test and Post-test groups was statistically significant (0% vs 26.47%, P = .004). Of the 9 sections of the rubric, 8 improved significantly (P < .05). The physician-patient relationship was the only one that did not show statistical significance, however, it did show improvement (88.2% vs. 100%, P = .125).  | Good/#6404/ Design of an educational intervention based on simulation for the development of clinical competence in neurological examinations.  |
| Ospel, et al. (2021)   | Survey, investigative   |  Simulation   | 1 | Neuroradiology   | Neurointerventionalists   | No comparison group   | Full Text   | *Journal of Neurointerventional Surgery*  | A web-based international multidisciplinary survey was conducted among neurointerventionalists. Participants were asked for their perceptions on the usefulness of current simulation tools and the potential impact of future simulation tools in endovascular UIA treatment.  | 233 neurointerventionalists from 38 countries completed the survey, most of whom (157/233 (67.4%)) had access to a simulator as a trainee, but only 15.3% used it frequently. Most participants (117/233 (50.2%)) considered currently available simulation tools relatively useful for endovascular UIA treatment, with greater value for trainees than for staff. Simulation of new devices (147/233 (63.1%)) and virtual practice runs in individual patient anatomy (119/233 (51.1%)) were considered most valuable for reducing endovascular UIA treatment complications.  | Good/#6334/ Current and future usefulness and potential of virtual simulation in improving outcomes and reducing complications in endovascular treatment of unruptured intracranial aneurysms.  |
| **He, et al. (2021)**  | **Investigational study, comparison study**  | **eLearning**  | **1** | **Clinical Neurology**  | **92 medical students**  | **Comparison of 3 separate groups based on level of training**  | **Full Text**  | ***Medical Education Online***  | **After completing the online course, the final scores and evaluation results were compared among different groups of interns, and their preference to distinct contents of the course was analyzed.** | **The online course received consistent positive recognition from the interns. Ninety-nine percent of the interns recommended incorporating the online course into the conventional offline training program after the pandemic. There was no significant difference between interns from different programs concerning the final scores and course evaluation. A smaller learning group size (<15 students) could achieve a better teaching effect than a larger group size (p < 0.05). The interns preferred interactive discussions, and course contents that they can get practice and feedback from, rather than video watching and didactic lectures.** | **Good/#5602/ Remote clinical training practice in the neurology internship during the COVID-19 pandemic.** |
| **Oster, et al. (2021)**  | **Investigational, interventional study**  | **ELearning, online webinar**  | **1** | **Clinical Neurology**  | **Medical students**  | **No comparison group**  | **Full Text**  | ***GMS Journal for Medical Education***  | **performed online evaluations to ensure an immediate feedback from the students.**  | **voluntary online evaluations were conducted after each block in which 63 of 155 students participated. The overall satisfaction with the course was rated as good with 3.9 out of 5 points, whereby the satisfaction with the learning progress was rated 3.8 out of 5 for the neurological anamnesis and 3.7 out of 5 for the examination technique.** | **Good/#5814/ Neurological examination course in an interactive webinar as a solution during a pandemic. An overview of the implementation, optimization as well as critical considerations.**  |
| Kulkarni, et al. (2012)   | Cross-sectional, observational study   | PBL | 1 | Clinical Neurology   | 140 medical students   | No comparison group   | Full Text   | *Journal of Clinical and Diagnostic Research*  | The integrated sessions involved in class discussions of the clinical cases and were designed, implemented and moderated by two faculties (clinicians and basic science faculty). Collected data were entered into MS Excel, and analysis was done using SPSS software. The students’ feedback regarding the perception of integrated teaching was collected on the Five point likerts scale using a validated questionnaire and analysed.  | The number of students included in the study was 140. About 135 (96.4%) of the students felt that integrated teaching using multiple case scenarios motivates them to learn in a better way. About 133 (95%) of students felt that integrated teaching helps them to understand concepts well, stimulates the critical thinking. About 136 (97.14%) of students felt that integrated teaching helped them to understand the topic in a holistic way.  | Good/#5682/ Multiple case scenarios based integrated teaching among first year medical students - A cross-sectional study.  |
| Narayanan, et al. (2021)   | Mixed-method, interventional study   | Role Play, TAG  | 1 | Clinical Neurology   | 142 medical students   | Cohort A vs Cohort B  | Full Text   | *Advances in Physiology Education*  | Cohort A received a didactic lecture on NMT and subsequently tested their knowledge of the topic via test 1, after which their perceptions of didactic lectures were recorded. The students were then asked to participate in a touch and-go (TAG) active-learning session regarding NMT, after which their learning was subsequently tested by taking test 2. Their perceptions about the TAG game were also recorded  | A comparison of the lecture followed by the game used in cohort A with the game blended lecture used in cohort B revealed no significant differences. However, both formats created a positive influence on students’ interest in learning the concept, and the students preferred active learning over didactic sessions alone.  | Good/#5610/ Appraisal of a novel pedagogical approach to demonstrating neuromuscular transmission to medical students.  |
| Pei, et al. (2021)   | Interventional, investigational study   | Simulation   | 1 | Clinical Neurology   | 17 physicians   | No comparison group   | Full Text   | *IEEE Robot. Autom.*  | The simulator was evaluated by a group of 17 experienced physicians and physical therapists. Subjects were instructed to induce sustained clonus using their normal technique. The simulator was assessed in two common clinical positions (seated and supine). Subjects scored simulation realism on a variety of control features.  | On average, all subjects could successfully trigger a sustained clonus response within 4-5 attempts in the first position and 2-3 in the second. Feedback on the fidelity of simulation realism improved between Day 1 and Day 2  | Good/#6348/ Design and Clinical Validation of a Robotic Ankle-Foot Simulator with Series Elastic Actuator for Ankle Clonus Assessment Training.  |
| Harris, et al. (2021)   | Investigationalstudy   | Simulation   | 0 | Clinical Neurology   | Medical students   | No comparison group   | Full Text   | *Cureus*  | adapted the validated questions from the “Simulation Evaluation Tool - Modified” for our post-simulation survey, which will detect the students’ level of confidence and their perceived learning post-simulation.  | N/A  | Good/#6047/ The Big Bang: A Virtual Subarachnoid Hemorrhage Simulation for Preclinical Medical Students.  |
| Ochoa, et al. (2012) | Interventional, investigational study | eLearning | 2 | Clinical Neurology, EEG | 20 neurologists | No comparison group | Full Text | *Epilepsy Currents* | A 40-question pretest exam was performed before training. The training included 4 online learning units about basic EEG principles and 40 online clinical EEG tutorials. In addition there were weekly live teleconferences for Q&A sessions. At the end of the program, the participants were asked to complete a posttest exam. R | Fifteen of 20 participants successfully completed the program and took both the pre and posttest exams. All the subjects scored significantly higher in the posttest compared to their baseline score. The average score in the pretest evaluation was 61.7% and the posttest average was 87.8% (p = .0002, two-tailed). | Good/#176/ A virtual training program to train community neurologists on EEG reading skills. |
| Familiari, et al. (2013) | Cross-sectional study | eLearning, enhanced imaging | 2 | Neuroanatomy | Medical students | Students who attended intervention vs those who did not | Full Text | *Anatomical Sciences Education* | Anonymous questionnaires, evaluated according to the Likert scale, demonstrated that students appreciated this teaching procedure. | Academic performance (examination grades for neuroanatomy) of the students who attended all integrated lectures of neuroanatomy, was slightly though significantly higher compared to that of students who attended these lectures only occasionally or not at all (P<=0.04). Significantly better results were obtained during the national progress test (focusing on morphology) by students who attended the MRI/DTI-assisted lectures, compared to those who did so only in part or not at all, compared to the average student participating in the national test. These results were obtained by students attending the second, third and, in particular, the fourth year (P<=0.0001) courses during the three academic years mentioned earlier. | Good/#209/ The value of neurosurgical and intraoperative magnetic resonance imaging and diffusion tensor imaging tractography in clinically integrated neuroanatomy modules: a cross-sectional study |
| Besne, et al. (2020) | Interventional study, pilot sudy | eLearning, Simulation | 2 | Clinical Neurology, Cranial nerves | 11 2nd year medical students, 10 4th year medical students, 4 neurologists | No comparison group | Full Text | *Acta Ophthalmology* | Participants were asked about usefulness and realism after performing the test mode. Validity evidence (relation with other variables) and content validity were evaluated. Kruskal–Wallis and Mann–Whitney U tests were used for comparisons. | All groups reported high scores in the content validity. The two questions with the highest score were related to the recommendation of the application. The expert group considered that the simulator showed a good level of realism (4.4/5). In relation with validity evidence, the average scores +/- standard deviation, including all pathologies, showed a significant difference between G1 and G2 (1.43 +/- 1.66 vs 4.12 +/- 2.50; p<0.001); G1 and G3 (1.43 +/- 1.66 vs 5.63 +/- ; 2.22; p=0.001); G2 and G3 (4.12 +/- 2.50 vs .63 +/- 2.22; p<0.001). | Good/#5222/ Validity evidence of SIMUL-Eye: eye movement and pupillary reflex simulator. |
| Schaefer, et al. (2020) | Interventional study, pilot study | eLearning, web-based curriculum | 2 | Clinical Neurology | 9 neurology residents | No comparison group | Full Text | *Clinical Parkinsonism and Related Disorders* | Evaluation of the curriculum was performed using pre- and post-tests, a survey, and semi-structured interviews. | The mean pre-test score was 0.7 (±0.19), and the mean post-test score was 0.95 (±0.05) (t = 3.27). Surveys demonstrated mean Likert values >4/5 for all questions in all categories (knowledge acquisition, quantity, enthusiasm and technical). Semi-structured interviews revealed the following themes: 1) the modules increased participant comfort with the topic, 2) the format was engaging, and 3) the curriculum accommodated different learning styles. All participants remarked that the structured framework was a particular strength. | Good/#1833/ An online curriculum in movement disorders for neurology. |
| Jung H, et al. (2018) | Interventional study | Flipped classroom | 2 | Clinical Neurology | 40 medical students | Flipped classroom method vs lecture based class | Full Text | *Korean Journal of Med Educ* | After performing flipped learning, formative assessment was conducted and the degree of satisfaction was examined. Questionnaires of satisfaction were developed to identify the perceptions of students on flipped learning. To compare the academic achievement of students, formative assessments were conducted at the end of the flipped learning class and the lecture class. | The students showed a high level of frequency in using lecture notes (80.6%) and lecture slides (74.2%) among the pre-class learning resources. The average score (3.89) was higher for the factor of interaction and collaboration in the classroom than for the factor of improving learning (3.62). The average score of the students in the formative assessment was 4.28 points (out of 10 points) in the lecture class, while it was 5.56 points (out of 10 points) in the flipped learning class thus showing a statistically significant difference (t=-4.203, p<0.001). | Good/#3911/ Analysis of satisfaction and academic achievement of medical students in a flipped class. |
| Fraser, et al. (2019) | Cross-sectional comparison study | PBL | 2 | Clinical Neurology, concussions | 148 medical students | Spiral curriculum (PBL) vs block curriculum | Full Text | *BMC Med Educ* | Cross-sectional online survey distributed via email to UBC medical students during the 2015–2016 academic year. Questions focused on demographic data, knowledge of concussion definition, and management considerations. | 78 students in the spiral curriculum and 70 students the block curriculum. Important differences between responses from spiral versus block curricula students included: formal exposure to concussion-related educational material (10.8 h spiral vs. 3.95 h block), understanding concussions can occur without direct head impacts (90% spiral vs. 70% block, p = 0.002) and identifying long-term consequences (dementia: 90% spiral vs. 66% block, p < 0.0001; second impact syndrome: 80% spiral vs. 57% block, p = 0.003; Parkinsonism: 47% spiral vs. 17% block, p < 0.001). | Good/#3763/ Cross-sectional comparison of spiral versus block integrated curriculums in preparing medical students to diagnose and manage concussions. |
| Stone, et al. (2017) | Comparison study, interventional study | Simulation | 2 | Clinical Neurology | 56 3rd year medical students (intervention), 131 control | Intervention group vs control group | Full Text | *Neurology* | An anonymous survey was conducted at the end of each clerkship block assessing student exposure to bedside skills modeling. | A total of 57.4% (95% confidence interval [CI] 43.3%–71.5%) of students in the modeling group reported observing both a comprehensive history and neurologic examination vs 37.5% (95% CI 28.2%–46.8%) in the non-modeling groups (p 5 0.023) | Good/#1027/ Education Research: Positive effect of scheduled faculty modeling on clerkship student bedside skills exposure and learning. |
| Alvarez-Sanchez, et al. (2019) | Experimental study, interventional | Simulation | 2 | Clinical Neurology | 34 Medical students | No comparison group | Full Text | *Educ. Med.* | All received the IEBS, which consisted of a 60-minute session with a neurology expert, 2 hands-on 30 minutes’ sessions with a Standardized Patient and feedback and a general 60- minute feedback. All participants were evaluated before and after the IEBS using the basic clinical skills in neurology rubric (HCBN) that considers 9 aspects of neurological examination. | No participant had the CCEN prior to the IEBS, and 9 developed it afterwards. Using the McNemar test, the difference in the CCEN between the Pre-test and Post-test groups was statistically significant (0% vs 26.47%, P = .004). Of the 9 sections of the rubric, 8 improved significantly (P < .05). The physician-patient relationship was the only one that did not show statistical significance, however, it did show improvement (88.2% vs. 100%, P = .125). | Good/#4829/ Design of an educational intervention based on simulation for the development of clinical competence in neurological examinations. |
| Haji, et al. (2016) | Interventional study  | Simulation | 2 | Clinical Neurology | 38 medical students | Simple task group vs complex task group | Full Text | *Medical Education* | Assessed LP performance and cognitive load on each trial using multiple measures. | In both groups, LP performance improved significantly during skill acquisition (p ≤ 0.047, f = 0.29–0.96) and was maintained at retention. The simple task group demonstrated superior performance compared with the complex task group throughout these phases (p ≤ 0.002, d = 1.13–2.31). Cognitive load declined significantly in the simple task group (p < 0.009, f = 0.48–0.76), but not in the complex task group during skill acquisition, and remained lower at retention (p ≤ 0.024, d = 0.78–1.39). Between retention and transfer, LP performance declined and cognitive load increased in the simple task group, whereas both remained stable in the complex task group. At transfer, no group differences were observed in LP performance and cognitive load, except that the simple task group made significantly fewer breaches of sterility (p = 0.023, d = 0.80). | Good/#2669/ Thrive or overload? The effect of task complexity on novices’ simulation‐based learning. |
| Barsuk, et al. (2012) | Interventional, comparison study | Simulation | 2 | Clinical Neurology, Lumbar puncture | 58 PGY-1 internal medicine residents, 36 PGY2-4 neurology residents | Internal medicine residents (simulation group\_ vs. Neurology residents | Full Text | *Neurology* | Fifty-eight internal medicine residents received an SBML intervention in LP, completed a baseline skill assessment (pretest). After a 3-hour session featuring deliberate practice and feedback, completed a posttest. Simulator-trained residents’ pretest and posttest scores were compared to assess the impact of the intervention. Thirty-six PGY2, 3, and 4 neurology residents from 3 medical centers completed the same simulated LP assessment without SBML. | PGY1 internal medicine residents improved from a mean of 46.3% to 95.7% after SBML (p 0.001) and all met the MPS at final posttest. The performance of traditionally trained neurology residents was significantly lower than simulator-trained residents (mean 65.4%, p 0.001) and only 6% met the MPS. | Strong/#171/ Simulation-based education with mastery learning improves residents' lumbar puncture skills |
| MacDougall, et al. (2014) | Interventional, investigational study | Simulation | 2 | Clinical Neurology, Brain death | 90 physicians total, 38 completed simulation | Compared specialities (neurology, neurosurgery, etc. ) | Full Text | *Neurocritical care* | Facilitators evaluated performance with a 26- point checklist based on the most recent AAN guidelines | Ninety physicians from multiple specialties have participated in the didactic session, 38 of whom have completed the simulation. Pre-test scores were poor (41.4 %), with attendings scoring higher than residents (46.6 vs. 40.4 %, p = 0.07), and neurologists and neurosurgeons significantly outperforming other specialists (53.9 vs. 38.9 %, p = 0.003). Post-test scores (73.3 %) were notably higher than pre-test scores (45.4 %). Participant feedback has been uniformly positive | Good/#243/ Simulation-based training in brain death determination. |
| Tan, et al. (2011) | Blinded, crossover study | TBL (Team based learning) | 2 | Neurological emergencies | 49 total 3rd year medical students | TBL vs PL (passive learning) | Full Text | *BMC Medical Education* | 3 closed book tests (pre/ 2 post) | Mean percentage change in scores was greater in the TBL versus the PL group in post-test 1 (8.8% vs 4.3%, p = 0.023) and post-test 2 (11.4% vs 3.4%, p = 0.001). | Strong/#3771/ A controlled study of team-based learning for undergraduate clinical neurology education. |
| Anwar, et al. (2020) | Interventional study | Team based learning (TBL) | 2 | Clinical Neurology/Neuroscience | 461 medical students | TBL vs non TBL cohorts | Full Text | *Advances in physiology education* | To compare student performance after TBR, average grades and marks obtained by cohorts of students undertaking NEU 241 before the implementation of TBR (2013/14 –2016/17; before TBR) were noted for comparison. A Student satisfaction, attitude, and opinion regarding the organization and implementation of NEU 241 was gauged using a nine-question student questionnaire, whereby student responses were gauged using a 5-point Likert scale. | The implementation of TBR in the NEU block curriculum led to an increase in the average mark obtained, as opposed to the average NEU mark obtained by students in cohorts before TBR (75.2 and 70.7%, respectively; P 0.05). The cohorts with TBR obtained higher proportions of grade A compared with those without TBR (41.2 vs. 26.9%), while the proportions of B (38.8 vs. 42.1%) and C grades (1.3 vs. 13.6%) fell significantly (P 0.05) in cohorts after TBR compared with those before TBR. | Good/#1926/ Implementation of structured team-based review enhances knowledge consolidation and academic performance of undergraduate medical students studying neuroscience. |
| Ekstrand, et al. (2018) | RCT, comparison study | VR | 2 | Neuroanatomy | 66 participants (1st-2nd year med students) | VR group vs paper-based group (control) | Full Text | *CMAJ* | Spatial relations between neural structures for 12 minutes after performing a neuroanatomy baseline test, with both test and control questions. A postintervention test was administered immediately after the study period and 5–9 days later. Satisfaction measures were also obtained. | The 2 groups performed comparably on the baseline questions and showed significant performance improvement on the test questions following study. There were no significant differences between groups for the control questions, the postintervention test questions or the 7-day postintervention test questions. Satisfaction survey results indicated that neurophobia was decreased. | Strong/#3364/ Immersive and interactive virtual reality to improve learning and retention of neuroanatomy in medical students: a randomized controlled study. |
| Johnson, et al. (2014) | Randomized, Interventional study | VR, Team based learning (TBL) | 2 | Clinical Neurology | 78 medical students | Individual vs 3 person teams | Full Text | *Medical teacher* | Learning was measured through diagnosis accuracy and pre-/post-simulation knowledge scores. Perspectives of learning context were collected post-simulation. | Students in teams submitted correct diagnoses significantly more often than students as individuals for CN-IV (p = 0.04; team = 86.1%; individual = 65.9%) and CN-VI (p = 0.03; team = 97.2%; individual = 80.5%). At pre-test scores ≤25.8%, students in teams scored significantly higher (66.7%) than students as individuals (43.1%) at post-test (p = 0.03) | Strong/#927/ Virtual patient simulations and optimal social learning context: a replication of an aptitude-treatment interaction effect |
| Douglas, et al. (2012) | Interventional study | Simulation | 2 | Clinical Neurology, Brain death | 18 neurology residents | No comparison group | Full Text | *Journal of graduate medical education* | Assessemnt scoring occurred via checklists consisted of 15 clinical skills, 9 apnea test–related skills, and 37 verbal skills related to family discussion. The 2-hour postintervention assessment repeated the brain death examination and family discussion simulations. | A total of 18 residents (100%) were assessed, with significant differences between preintervention and postintervention testing across all areas, including clinical assessment (45%–76%, P , .001), apnea testing (57%–92%, P , .001), and verbal communication (46%–73%, P , .001). | Good/#2012/ Simulation-Based Training in Brain Death Determination Incorporating Family Discussion |
| Anwar et al. (2015) | Interventional study | Team based learning (TBL) | 2 | Clinical neurology | 156 medical students | TBL attendees vs non-attendees | Full text | *Medical education online* | Individual and team-based assessments | Found that students who attended TBL sessions performed better in the summative examinations as compared to those who did not. Furthermore, students performed better in team activities compared to individual testing, with male students performing better with a more favorable impact on their grades in the summative examination. There was an increase in the number of students achieving higher grades (grade B and above) in this block when compared to the previous block (51.7% vs. 25%) | Good/#249/ Tackling student neurophobia in neurosciences block with team-based learning |
| Pablo, et al. (2019) | Feasibility study, retrospective review | 3-D modeling/printing | 1 | Neuroanatomy | N/A | No comparison group | Full Text | *Annals of Medicine* | Surface scanning technologies such as 3D scanners and photometry software were used to obtain 3D models made from anatomical dissection models in cadaveric material. | An online platform, easily accessible and multiplatform, was created with 50 three-dimensional topographic models of different anatomical structures, which allow users to view all angles of the anatomical piece. | Good/#1531/ New technologies applied to the study and application of digital anatomy. HDM project (human dissection models). 5 years of experience |
| Dao, et al. (2015) | Interventional study | Art- based learning | 1 | Neuroanatomy | 1st year medical students | No comparision group | Full Text | *Anatomical sciences education* | At each session, students reviewed the neurosensory pathways through structured presentations and then applied them to preplanned interactive activities, many of which allowed students to utilize their artistic talents. Students were required to complete subjective pre-course and post-course surveys and reflections. | The survey results and positive student comments suggest that the elective was a valuable tool when used in parallel with the traditional medical neuroscience course in promoting engagement and reinforcement of the neurosensory material. | Good/#289/ Applied neuroanatomy elective to reinforce and promote engagement with neurosensory pathways using interactive and artistic activities. |
| Moeller, et al. (2017) | Interventional study | eLearning | 1 | Clinical Neurology, EEG | 21 Neurology residents | No comparison group | Full Text | *The journal of teaching and learning resources* | A survey about the process was completed at the end of the year. | Twenty-one residents participated in the curriculum, and 15 (71%) responded to the survey. Two-thirds of respondents (10/15) said that they watched all of the videos, and 87% (13/15) watched at least half of the videos. All of the respondents used the videos as introductions to EEG concepts, and approximately half of respondents returned to the videos as a refresher after the rotation was over. Nearly all respondents either agreed or strongly agreed that the curriculum was a useful component of the rotation and helped them to understand difficult concepts. All strongly agreed that they would recommend the curriculum to other residents. | Good/#1001/A Video-Based Introductory EEG Curriculum for Neurology Residents and Other EEG Learners |
| Le Marne, et al. (2016) | Interventional Study | eLearning | 1 | Clinical Neurology | Pediatric neurologists, pediatricians, and nurses | No comparison group | Full text | *Journal of Pediatrics and Child Health* | Measures included general epilepsy knowledge, case-based scenario knowledge; self-rated measures of satisfaction with instruction and confidence regarding clinical approach to the child with first unprovoked seizure; and open ended questions evaluating the usefulness of the E-learning resource | Performance on measures of general epilepsy knowledge and on the seizure-related case scenarios improved significantly following completion of the E-learning as did self-rated satisfaction with instruction and confidence across all aspects of managing first seizure. | Good/#656/ Evaluation of an E-learning resource on approach to the first unprovoked seizure |
| Benjamin, et al. (2019) | Interventional Study | eLearning | 1 | Clinical Neurology | 37 residents | No comparison group | Full Text | *The Journal of Teaching and Learning Resources* | The curriculum has four components—multimedia PowerPoint with embedded video, knowledge assessment, clinical exam (CEX) assessment, and module feedback—and was completed by 37 residents over an 8-month period from January to September 2016. We utilized knowledge assessment, direct clinical skills observation using the CEX, and module-feedback responses as part of the evaluation | All 37 residents completed the curriculum, with an overall knowledge score of greater than 80%. Residents demonstrated most of the desired patient care behaviors on the CEX assessment and provided positive feedback on the quality, usefulness, and applicability of the module, in addition to requesting more curricula to develop their physical examination skills. | Good/#1550/A Blended Curriculum to Improve Resident Physical Exam Skills for Patients With Neuromuscular Disability. |
| Hernandez, et al. (2017) | Feasibility study | eLearning, digital images | 1 | Clinical Neurology | N/A | No comparison group | Full Text | *Repertorio de Medicina y Cirugia* | The project was carried out in three phases, the first of which was the analysis and instructional design of the syllabus. The second and third phase included a literature search and review of clinical cases, followed by the entering of the OVA in the institutional platform. | The OVA was published in the institutional repository of OVAS for use by medical students, general practitioners, and first year residents of neurology and other specialties of the University Health Sciences Foundation. | Good/#733/ Interactive atlas of neuroimages and clinical correlation of images in acute cerebrovascular accident: Educational digital resources |
| Mortin, et al. (2016) | Interventional, qualitative study | eLearning/Blended learning | 1 | Clinical Neurology, Neurotransmitters/Neurodegenerative disorders | 26 4th year medical students | No comparison group | Full Text | *BMC Med Educ* | Computer literacy, student satisfaction | Respondents reported a high level of self-reported computer literacy and a high level of satisfaction with the module | Good/#3845/ Blended learning: how can we optimise undergraduate student engagement? |
| Greville, et al. (2016) | Interventional study | Equivalence-based learning (EBL) | 1 | Neuroanatomy | 106 medical students | No comparison group | Full Text | *Journal of Educational Evaluation of Health Professions* | Used a pre and post test design to assess students’ learning of the relations. Resources were evaluated by students for perceived usefulness and confidence in the topic. Three versions of the resources were designed, to explore learning parameters such as the number of stimulus classes and the number of relationships within these classes | Use of EBI resulted in demonstrable learning of material that had not been directly taught. The resources were well received by students, even when the quantity of material to be learned was high. There was a strong desire for more EBI-based teaching. | Good/#3573/ The student experience of applied equivalence-based instruction for neuroanatomy teaching. |
| Veeramani, et al. (2015) | Interventional study | Flipped classroom | 1 | Neuroanatomy | 130 1st year medical students | No comparison group | Full Text | *Anatomy & Cell Biology* | pre- and post-tests were designed to specifically test the declared learning objectives of the session. | Eighty-six percent of students felt that the flipped classroom approach was better at fulfilling the stated learning objectives than the conventional didactic teaching, 92% felt that the work-sheet with questions provided prior to the class enabled a better understanding of the subject and 87% were of the opinion that the web sources with references kindled a greater interest to read as compared with didactic lectures. The paired t test showed highly significant differences between the pre and post-test scores. | Good/#2815/ Perception of MBBS students to "flipped class room" approach in neuroanatomy module. |
| Wiznia, et al. (2012) | Interventional, pilot study | PBL  | 1 | Clinical Neurology | 1st year medical students | No comparison group | Full Text | *Medical Education Online* | At the conclusion of the course, students were asked to complete a survey to evaluate their satisfaction with PBL 2.0. | One hundred and six students were surveyed and 98 submitted answers (92% response). The majority of groups adhered to the new PBL method. Students invested more time preparing the learning objectives. Students indicated that the level of interaction among students increased. The majority of students preferred the new PBL format. | Good/#2549/ PBL 20: Enhancing problem-based learning through increased student participation. |
| Coggins, et al. (2017) | Interventional study | Simulation | 1 | Clinical Neurology, Non-technical skills | 283 medical students/junior doctors | No comparison group | Full Text | *Advances in Simululation* | The blended approach combined open access online resources with multiple opportunities to participate in simulation-based learning. The aim of the study was to examine the value of the program to the participants and the effects on the wider hospital system. The mixed methods evaluation included data from simulation centre records, hospital quality improvement data, and a post-hoc reflective survey of the enrolled participant. | Over 30 months, 283 junior doctors were invited to participate in the program. Enrolment in a designated simulation-based course was completed by 169 doctors (59.7%). Supplementary revision sessions were made available to the cohort with a median weekly attendance of five participants. 56/68 (82.4%) of survey respondents reported increased confidence in managing deteriorating patients. During the period of implementation, the overall rate of hospital cardiac arrests declined by 42.3%. | Good/#3275/ Early acquisition of non-technical skills using a blended approach to simulation-based medical education. |
| Valentine, et al. (2019) | Interventional Study | Simulation | 1 | Clinical Neurology | Neurology Resident | No comparison group | Full Text | *Epilepsy and Behavior* | Each encounter was observed by an attending physician who provided real-time feedback to the resident after the session. Additionally, the SP completed an objective written checklist of items the resident should have covered in the session and gave them verbal feedback. | Twenty-six adult neurology (n = 22), child neurology (n = 3), and neuropsychiatry (n = 1) residents participated in this OSCE in 2018 and 2019, with full data available for 25 participants. Residents reported the OSCE was very useful (mean Likert score of 4.9/5). They felt moderately prepared (mean Likert score 3.8/5) and rated their performance as a mean of 3.3/5. On the SP's checklist, most residents were rated as Well Done in the domains of information gathering, relationship development, and education and counseling. Only in the domain of psychosocial assessment were most residents rated as Not Done. | Good/#2055/ Objective Structured Clinical Exams (OSCE) are a feasible method of teaching how to discuss a nonepileptic seizure diagnosis. |
| Von Cranach, et al. (2019) | Interventional study | Simulation | 1 | Clinical Neurology, Lumbar puncture | 153 medical students | No comparison group | Full Text | *Brain and Behavior* | Students were asked to describe their practical experience in different bedside procedures, and document how they perceive LP in terms of their own knowledge, confidence and attitude. Students then participated in a newly designed 90‐min seminar, including simulation. All students who completed the seminar were required to complete the survey for a second time. | Among the 153 participants, LP was associated with the lowest baseline levels of experience and confidence compared to other bedside procedures. Attitudes, knowledge, and confidence related to the various aspects of LP all showed significant improvement after the seminar. | GOOD/#1637/ Medical students' attitudes toward lumbar puncture—And how to change |
| Tung, et al. (2013) | InterventionL study | Simulation | 1 | Clinical Neurology, Lumbar puncture | 20 PGY2-5 Neurology residents | No comparison group | Full Text | *Neurology* | Electronic survey after atraumatic needle for lumbar puncture. | Eleven residents (92%) who used the atraumatic needle said they would use it again for future lumbar punctures. The most common reasons cited for wanting to continue to use the atraumatic needle were to prevent post–lumbar puncture headaches, to choose the cost-effective option, and to stay up-to-date with changes in practice. | Good/#1277/ Education research: Changing practice: Residents' adoption of the atraumatic lumbar puncture needle |
| Hirumi, et al. (2016) | Investigational, feasibility study, overview of design | Simulation | 1 | Clinical Neurology | N/A | No comparison group | Full Text | *Education Technology Research Development* | Examined the design and development of NERVE: A virtual patient simulation created to give medical students standardized experiences in interviewing, examining, and diagnosing virtual patients with cranial nerve disorders. | Depict key design features of the simulation and discuss how two sets of design research studies were completed to improve the total learning experience, including the virtual patient simulations and the instructional features incorporated with the simulations. | Good/#2364/ Advancing Virtual Patient Simulations through Design Research and InterPLAY: Part I--Design and Development. |
| Kurzweil, et al. (2020) | Investigative study, interventional study | Simulation | 1 | Clinical Neurology | 57 neurology residents | No comparison group | Full Text | *Neurology* | Faculty members lead a 30-minute debriefing session during which residents discuss their experience and review take-away pearls. Post simulation anonymous survey. | 57 residents who participated in the OSCEs agreed the OSCE cases were similar to real-life encounters (mean score 4.1/5 [with 5 being strongly agree and 1 being strongly disagree]), but were neutral about whether their performance on OSCEs adequately reflected their performance in practice (mean 3.4/5). The residents believed the OSCEs were very useful (mean score 4.7/5, with 5 being most useful). | Strong/#1861/ Education Research: Teaching and assessing communication and professionalism in neurology residency with simulation |
| Watson, et al. (2019) | Case Study | Team Based Learning | 1 | Clinical Neurology | 31 medical students | No comparison group | Full Text | *J Undergrad Neurosci Educ* | Students ‘diagnose’ the etiology of a composite patient’s symptoms using behavioral, neurological, neuroimaging, and electrophysiological test results. | Students also generally felt that the case was successful in meeting learning goals. 96% of students “agreed” or “strongly agreed” that the case “…increased my knowledge about the symptoms and causes of locked-in syndrome” and 81% “agreed” or “strongly agreed” that it “…helped me increase my knowledge [sic] event-related potentials and brain computer interfaces”. No respondents “disagreed” or “strongly disagreed” with either of these questions. In the content probe, 90% (28/31) of respondents correctly identified the pons as a typical locus of damage in locked-in syndrome. | Good/#2952/'Without A Key': A Classroom Case Study. |
| Souza, et al. (2020) | Feasibility study | 3-D modeling/printing | 0 | Neuroradiology | N/a | No comparison groups | Full Text | *Arquivos de Neuro-Psiquiatria* | Primary outcome: developing an endovascular technique simulator using 3D printing technology. | Meetings were held between the neuroradiologist specialist and programmers to develop the simulator, which was carried out in three phases: design of the arterial system, design of the prototype of the arterial system in computer graphics, and confection of the arterial system simulator in 3D. | Poor/#1980/ Endovascular technique simulator for neuroradiology learning |
| Scott, et al. (2014) | Interventional study | eLearning/web based/peer education, “Shadow Module” | 0 | Clinical Neurology, Neuroanatomy | Total n/a, 15-20 medical students per module | No comparision group | Full Text | *Journal of Anatomy* | N/A | N/A | Poor/#892/ Building an open academic environment - a new approach to empowering students in their learning of anatomy through 'Shadow Modules' |
| Zeiger, et al. (2020)   | Survey study   | Smart phone  | 1 | Clinical Neurology   | Neurology trainees, attendings   | Compared responses of trainees and attending physicians   | Full Text   | *JMIR mHelath and uHealth*  | We developed a 31-item electronic questionnaire to address these questions and invited neurology trainees and attendings of all residency programs based in the United States to participate. We summarized descriptive statistics for respondents and specifically compared responses between trainees and attending physicians.  | Received 213 responses, including 112 trainee and 87 attending neurologist responses. Neurology trainees reported more frequent use of their smartphone for patient care–related activities than attending neurologists (several times per day: 84/112, 75.0% of trainees; 52/87, 59.8% of attendings; P=.03). The most frequently reported activities were internet use, calendar use, communication with other physicians, personal education, and health care–specific app use. Both groups also reported regular smartphone use for the physical examination, with trainees again reporting more frequent usage compared with attendings (more than once per week: 35/96, 36.5% of trainees; 8/58, 13.8% of attendings; P=.03).  | Good/#5823/ Patterns and Perceptions of Smartphone Use Among Academic Neurologists in the United States: Questionnaire Survey.  |
| **Carrazoni, et al. (2021)**  | **Interventional study**  | **eLearning**  | **1** | **Clinical Neurology, neurophysiology**  | **Medical students**  | **No comparison group**  | **Full  Text**  | ***Advances in physiology education***  | **sent a questionnaire to 49 participants who finished the course.**  | **We found that although most students (52.5%) had never taken a course with similar methods before, almost all of them (95%) liked the flipped class model. Additionally, a majority of the students (92.5%) said that the method increased their study frequency during the social distancing period,** | **Good/#5611/ Report on the online course "Basic Concepts in Neurophysiology": a course promoted during the COVID-19 pandemic quarantine.**  |
| Fahy, et al. (2021)   | Investigational, interventional, pilot study   | Simulation   | 2 | Clinical Neurology, EEG   | 24 Neurology residents   | No comparison group   | Full Text   | *Neurological Sciences*  | Total percent correct for each scenario and average percent correct for all scenarios were calculated and correlated with most recent In-training Examination (ITE) and United States Medical License Examination (USMLE) scores.  | Neurology residents’mean percent correct scenario scores ranged from 27.1–86.0% with an average scenario score of61.2% ± 7.7. We showed a moderately strong correlationr= 0.49 between the ITE and the average scenario score.  | Good/#6184/ An online, interactive, screen-based simulator for learning basic EEG interpretation.  |
| Vinny, et al. (2021)  | Cross-sectional multicenter study   | Smart phone App  | 2 | Clinical Neurology   | 100 neurology residents   | No comparison group   | Full Text   | *Indian Journal of Ophthalmology*  | The differentials generated by residents and the App were compared with the Gold standard differential diagnoses adjudicated by experts. The prespecified primary outcome was the proportion of correctly identified high likely gold standard differential diagnosis by residents and App  | Neurology residents (n = 100) attempted 1500 Neuro‑ophthalmology clinical vignettes. Frequency of correctly identified high likely differential diagnosis by residents was 19.42% versus 53.71% by the App (P < 0.0001). The first listed differential diagnosis by the residents matched with that of the first differential diagnosis adjudicated by experts (gold standard differential diagnosis) with a frequency of 26.5% versus 28.3% by the App, whereas the combined output of residents and App scored a frequency of 41.2% in identifying the first gold standard differential correctly. The residents correctly identified the first three and first five gold standard differential diagnosis with a frequency of 17.83% and 19.2%, respectively, as against 22.26% and 30.39% (P < 0.0001) by the App.  | Good/#5662/ Mobile application as a complementary tool for differential diagnosis in Neuro-ophthalmology: A multicenter cross-sectional study.  |
| Todnem, et al. (2021)   | Interventional, feasibility study   | 3-D Modeling   | 1 | Clinical Neurology, EVD placement   | 10 medical students   | No comparison group   | Full Text   | *Journal of Neurosurgery*  | The students were surveyed on their experience with using the brain model, including usability and practicality of the model. Accuracy of EVD placement by each student was also assessed, with adequate position of catheter tip being in the ipsilateral frontal horn.  | The final product is fairly inexpensive and easy to make. It is soft enough to pass a catheter through, but it is also firm enough to maintain its shape, including a cavity representing the lateral ventricles. The dense gelatin holds the catheter in its final resting position, while the two halves are separated and inspected. All participants in the test group of medical students reported that the brain model was easy to use, helped them understand the steps and technique of EVD placement, and provided good feedback on the ideal position of ventricular catheters. All of the participants in the group had adequate positioning of their ventricular catheters after one attempt.  | Good/#5681/ A simple and cost-effective model for ventricular catheter placement training: Technical note.  |
| Porter-Stransky, et al. (2021)  | Interventional Study   | Case based   | 1 | Neuroanatomy   | 2nd year medical students    | No comparison group   | Full Text   | *Med Sci Educ*  | As part of the normal course evaluation process, a subset of the class was asked to rate the event on a three-level Likert-type scale.  | The sampled students rated the laboratory event2.54 out of 3 (1 = unsatisfactory, 2 = satisfactory, 3 = out-standing). Comments in the course evaluation revealed that this laboratory-style event was well received by most students,who reported that it helped them integrate neuroscience, neuroanatomy, and psychiatry content.  | Good/#6001/ A Case-Based Neuroanatomy Laboratory on the Neurobiology of Psychiatric Conditions for Second-Year Medical Students.  |
| Hart, et al.  (2021)   | Investigational study   | eLearning   | 1 | Neuroanatomy   | Medical Students   | No comparison group   | Full Text   | *Journal of Medicine Education Curriculum*  | Student usage data, single-session course evaluations, and a focus group were used to evaluate the module’s effectiveness.  | Student usage data showed an average completion time of M =2:59:25 hours which fit within the scheduled 3-hour timeframe. Students rated the module’s overall effectiveness as M =3.65 (out of 4) on a single-session evaluation. A focus group provided qualitative feedback suggesting improvements to the eLearning module in the domains of content, mechanics, and timing.  | Good/#6008/ A Qualitative Examination Detailing Medical Student Experiences of a Novel Competency-Based Neuroanatomy eLearning Intervention Designed to Bridge a Gap Within an Integrated Medical Curriculum.  |
| Wu, et al. (2020)   | Interventional, feasibility study   | Gamification   | 1 | Neuroradiology   | 61  residents   | No comparison group   | Full Text   | *Journal of the AMerican College of Radiology*  | performed an anonymized, voluntary, institutional review board–exempt online survey to assess resident attitudes and their attendance habits. All 61 residents (residency years 1-4) were surveyed, and questions were predominantly phrased using 5-point Likert scale or true-or-false formats.  | Before implementation, 22 of 61 (36%) residents responded to the survey and 25 of 61 (41%) responded afterward. Significant differences were found in awareness of the existence of a neuroradiology curriculum (increasing from 18% to 76%, P ¼ .0007), and the number of residents who thought the curriculum was “organized” or “very well organized” (P ¼ .005). No significant differences were found in how well residents believed the curriculum prepared them for rotations, call, or CORE examination. However, a greater percentage of learners believed that the redesigned curriculum prepared them “well” or “very well” as compared with before.  | Good/#5845/ Winter Is Here: A Case Study in Updating the Neuroradiology Didactic Curriculum Through a Gamification of Thrones Solution.  |
| McGovern, et al. (2021)   | Cross-sectional, investigational study   | Role Play   | 1 | Clinical Neurology, neurophobia   | 395 medical students   | No comparison group   | Full Text   | *Journal of Neurological Sciences*  | Part one: a cross-sectional study to validate a newly constructed neurophobia scale, NeuroQ. Part two: a prospective longitudinal study to assess the impact of The Move on student neurophobia using NeuroQ. A population-based sample of second-year medical students of the 2019 and 2020 class of the Faculty of Medicine of Sorbonne University were invited to participate.  | NeuroQ incorporates the main themes of the neurophobia definition and demonstrates unidimensionality. Three hundred and ninety-five medical students participated in the study (mean age was 20.0 years, SD: 2.1 years) assessing the effect of The Move teaching on neurophobia. Two hundred and eighty-eight (72.9%) students were female. After the Move teaching the mean NeuroQ score was significantly lower compared to the baseline NeuroQ score (mean [SD] variation, − 1.1 [2.6], p < 0.001). There was a 22.3% relative reduction in the number of neurophobic students after The Move teaching.  | Good/#5753/ NeuroQ: A neurophobia screening tool assesses how roleplay challenges neurophobia.  |
| Carroll, et al. (2021)   | -Investigational, interventional study  | Simulation   | 1 | Clinical Neurology   | 57 3rd and 4th year medical students   | No comparison group   | Full Text   | *Journal of STroke and Cerebrovascular Disease*  | The residents were surveyed on the experience using a Likert scale from 1 (worst) to 5 (best). The SP completed a behavioral anchored checklist and marked items as “not done,” “partly done,” or “well done”.  | 57 third and fourth year neurology residents completed the case from 2018 to 2020, 54 (95%) of whom completed the post-OSCE survey. Residents reported feeling moderately prepared for the simulation (mean Likert score 3.7/5), and thought their performance was average (3.4/5). Overall, they found the case to be very helpful (4.6/5). The residents performed well in the realms of maintaining professionalism (64% rated “well done”), developing a relationship (62% rated “well done”), and information gathering (61% rated “well done”). There was room for improvement in the realms of providing education and presenting the bad news (39% and 37% rated “partly/not done,” respectively)  | Good/#5638/ Using Objective Structured Clinical Exams (OSCE) to Teach Neurology Residents to Disclose Prognosis after Hypoxic Ischemic Brain Injury.  |
| Albert, et al. (2021)   | Investigational, interventional study   | Simulation   | 1 | Clinical Neurology   | Pediatric neurology trainees   | No comparison group  | Full Text   | *Pediatric Neurology*  | Each trainee standardized patient encounter was evaluated by an observing faculty member using a modified Gap-Kalamazoo Communication Skills Assessment Form, the standardized patient who provided direct feedback, and by the participating trainee.  | Results indicated rater agreement ranging from 32% to 56%. Trainees reported that the cases were challenging and reflective of real life and that the experience helped improve their communication skills.  | Good/#5776/ An Objective Structured Clinical Examination of Communication Skills for Child Neurology Residents.  |
| Monteiro, et al. (2021)   | Investigational, interventional study   | Simulation   | 1 | Clinical Neurology, neurophysiology   | 42 MBBS students   | No comparison group   | Full Text   | *Adv Physiology Education*  | Students were asked to submit their activity booklets at the end of the session. These were marked by faculty members according to the preagreed key.  Toward the end of the practical session, students were encouraged to complete an anonymous feedback survey on the activity.  | students were asked about the practical aspects of the activity, i.e., whether the activity booklet was easy to follow, whether they needed guidance from teachers, and whether they felt the teachers had sufficient knowledge of the subject matter and the activity. These data are summarized in Table 1. Eighty-one percent of responses agreed (20 students) or strongly agreed (10 students) that the activity booklet was easy to follow. Seventy percent of responses agreed (16 students) or strongly agreed (10 students) that they needed guidance from teachers. Students also thought that the teachers had sufficient knowledge of the subject and the activity, with 92% and 86% agreeing or strongly agreeing, respectively. No students disagreed or strongly disagreed that the teachers had sufficient knowledge of the subject or activity. Our data therefore suggest that the prior preparation of the activity involving faculty members was an important component.  | Good/#5998/ Teaching bioelectricity and neurophysiology to medical students using LabAXON simulations.  |
| Manu, et al. (2020)  | Interventional study   | TBL (team based learning)   | 1 | Clinical Neurology   | 106 IM, neurology residents   | No comparison group   | Full Text   | *MedEdPORTAL: the journal of teaching and learning resources*  | Case-based learning, small-group discussion, and learner reflection were employed. We assessed the impact on 82 of the 106 IM, medicine-pediatrics, and neurology residents who participated in the seminar.  | Participant evaluation indicated residents showed high satisfaction and perceived the educational content of the seminar to be robust and clinically relevant. We found statistically significant (p < .001) improvements in self-reported confidence in dementia-specific skills postseminar. Effect size was large to very large (Cohen’s d = 1.3-1.7)  | Good/#5840/ Eating Problems in Advanced Dementia: Navigating Difficult Conversations.  |
| Bjorn, et al. (2020)  | Interventional, investigational study   | VR  | 1 | Neuroanatomy   | 35 medical students   | Group 1 (experimental group 1) used the simulator with fuzzy feedback, group 2 (experimental group 2) used the simulator with exact feedback, and group 3 (control group) did not use a simulator  | Full Text   | *JMIR Serious Games*  | The study comprised pre- and posttests on theoretical knowledge and practical hands-on evaluation of EEG electrode placement.  | The Wilcoxon signed-rank test indicated that the two groups that utilized a computer-based electrode placement simulator showed significant improvement in both theoretical knowledge (Z=1.79, P=.074) and observed practical skills compared with the group that studied without a simulator.  | Good/#6117/ Learning Impact of a Virtual Brain Electrical Activity Simulator Among Neurophysiology Students: Mixed-Methods Intervention Study.  |
| Pickering, et al. (2021)   | Randomized, control trial, interventional study   | VR, mixed reality   | 1 | Neuroanatomy   | 2nd year medical students   | Traditional screencasts group vs. Mixed reality   | Full Text   | *Anatomical Sciences Education*  | pre- and post-test methodology was used on a cohort of Year 2 medical students, with both the absolute and normalized gain calculated.  | Similar patterns of learner gain were observed between the two groups; only the multiple-choice questionnaires (MCQs) were shown to be answered significantly higher with the screencast group.  | Strong/#5651/ Assessing the Difference in Learning Gain between a Mixed Reality Application and Drawing Screencasts in Neuroanatomy.  |
| Espy, et al. (2021)  | Interventional, investigational overview study   | VR  | 0 | Clinical Neurology   | N/A  | N/A  | Full Text   | *Frontiers of Neurology*  | It incorporates person (body segment), environmental, and task demands; each demand is comprised of realm, category, choice, and continuum parameters as motor training considerations and alternatives for decision-making.  | (1) provides structure to guide clinical decisions for effective and safe use of virtual reality or gaming to meet therapeutic goals and requirements, (2) is a concise and organized method to identify, document, and track the therapeutic components of protocols and client progression over time; (3) can facilitate documentation for reimbursement and communication among clinicians; and, (4) structures student learning, and (5) informs research questions and methods.  | Good/#5671/ A Clinical Decision-Making Framework for the Use of Video Gaming as a Therapeutic Modality.  |
| Mehta, et al. (2018) | Interventional study | Simulation | 4 | Neurological emergencies, Stroke | 2nd year neurology residents | Intervention group (simulation participants), patients treated with tpa prior and post simulation intervention | Full Text | *Journal of Graduate Medical Education* | Resident performance, critical action checklist completion, Door-to-needle time for IV-tPA | Simulation training independently predicted reduction in DTN time by 9.64 minutes (95% confidence interval [CI] –15.28 to –4.01, P ¼ .001) after controlling for age, night/day shift, work week versus weekend, and blood pressure at presentation (. 185/110). Systolic blood pressure higher than 185 was associated with a 14.28- minute increase in DTN time (95% CI 3.36–25.19, P ¼ .011) | Good/#1156/ Stroke Simulation Improves Acute Stroke Management: A Systems-Based Practice Experience |
| Maghalhaes, et al. (2014) | Non-inferiority comparative study | Clinical Decisions/Diagnostic Workshop (CD/DW) | 2 | Clinical Neurology, Stroke | Approx 72 medical students | CD/DW vs traditional lecture series | Full Text | *Arq Neuropsiquiatr* | Pre and postests, questionnaire | The comparative test showed the CD/DW approach to lead to slightly higher cognitive acquisition as opposed to the traditional method. The method was well accepted by teachers and students alike. | Good/#3459/ A Brazilian original pedagogical approach to the teaching of neurology. |
| Groth, et al. (2018) | Comparative study | eLearning | 2 | Neuroradiology, Imaging/CT interpretation | 100 medical students | ELearning group vs interactive teaching group vs control | Full Text | *Academic Radiology* | Posttest | the e-learning group and interactive teaching tutorial group both showed a significantly better performance in detecting hyperdense middle cerebral artery sign (p = 0.001 and p < 0.0001) as well as subarachnoid hemorrhage (p = 0.03 and p = 0.001) on CT | Good/#1476/ Critical Analysis of an e-Learning and Interactive Teaching Module with Respect to the Interpretation of Emergency Computed Tomography of the Brain |
| Havsteen, et al. (2012) | Interventional study | eLearning | 2 | Neurological emergencies, Stroke | 4 neurological consultants | No comparison group | Full Text | *Journal of Stroke Cerebrovascular Disease* | We developed an HTML-based program with a teaching segment and 2 matching test segments. Tests were taken before and after the teaching segment; the test size was 40% of the teaching segment size. We assessed diagnostic accuracy and readers’ confidence. | The vascular occlusion teaching segment increased diagnostic accuracy from 42% to 68% (P 5 .005). The neurologic consultants showed significant progress, with average scores of 50% versus 75% (P 5.027). The radiologic residents showed trend with progress, with average scores of 33% versus 60% (P 5.081). The entire group detected spot sign correctly 69% before versus 92% after teaching (P 5 .009) and reported a median self perceived diagnostic certainty of 50% versus 75% (P 5.030). Self-perceived diagnostic certainty revealed no significant increase for vascular occlusion. | Good/#3688/ E-learn computed tomographic angiography: a proposed educational tool for computed tomographic angiography in acute stroke. |
| Afshari, et al. (2019) | Pilot, Interventional study | eLearning | 2 | Clinical Neurology | 11 neurology residents (PGY3-4) | No comparison group. | Full Text | *Neurology* | Change in residents’ telemedicine knowledge and perspectives on the utility, challenges, benefits, and future practice implementation of tele neurology were evaluated in 11 residents using precurriculum and post curriculum quizzes and surveys after 2 of 4 weeks on the rotation. | Residents’ performance on quizzes improved from 53% to 88% (p = 0.002). Residents’ impression of video visits compared to in-person visits changed, with more individuals indicating video visits to be the same if not somewhat superior with regards to obtaining a focused history, formulating a focused assessment and plan, communicating recommendations, and the overall care provided (p ≤ 0.04). All residents felt more competent using telemedicine for patient care in their eventual career. | Good/#1783/ Education Research: An experiential outpatient tele neurology curriculum for residents |
| Kalet, et al. (2011) | Randomized, Interventional and comparative study | eLearning | 2 | Neurological emergencies, Stroke | 53 2nd year medical students | 4 module versions: movie (low, low), slider (low, high), click (high, low), and drag (high, high). | Full Text | *Journal of General Internal Medicine* | We developed the “Stroke Locator” (SL), a 3D representation of the cerebral vasculature where the student can use the computer mouse to drag an onscreen embolus into any part of the vascular tree and see what stroke syndrome is produced. In a randomized, factorial study design, we used this tool to investigate the effects of kinesthetic and cognitive design elements on the consequent learning. | 53 students completed the protocol: movie (15), slider (11), click (12), or drag (15). For clinical knowledge acquisition, measured by a multiple-choice test, students who did a module with high cognitive interactivity performed better than those doing one with low cognitive interactivity, regardless of the level of kinesthetic interactivity (Cohen’s d=0.52; 95% CI: 0.0, 1.0). However, for clinical reasoning, measured by MRI reading, students in the click group performed better than those who received the drag treatment (Cohen’s d=0.7; 95% CI: -0.1, +1.5 ). | Strong/#34/ You be the embolus: A study of interactive design features for learning the pathophysiology of thromboembolic stroke. |
| Gaetke-Udager, et al. (2018) | Interventional, comparison study | eLearning, computer-based learning | 2 | Neuroradiology | 31 Neurology residents | No comparison group | Full Text | *The journal of Teaching and Learning Resources* | Residents took 20- question pre- and posttests to assess knowledge and a postmodule survey. Each resident was randomized to one of two pretests and took the opposite as the posttest. | 31 neurology residents completed the module and the pre- and posttests. Scores for all residents either stayed the same or increased, regardless of the order of the versions of the pre- or posttests; the mean score increase was 4 (p < .0001) out of 20. Radiology residents had higher mean scores than neurology residents on the pre and posttests, which were statistically significant (p < .04 and .0004, respectively). Feedback on the survey was overwhelmingly positive. | Good/#1492/ An Introductory, Computer-Based Learning Module for Interpreting Noncontrast Head Computed Tomography. |
| Benjamin, et al. (2018) | Interventional study | eLearning, Flipped classroom | 2 | Clinical Neurology | 37 neurology residents | No comparison group | Full text | *Acad. Pediatr.* | Resident abilities on the physical exam were assessed by a standardized clinical exam exercise (CEX). | All 37 residents assigned to the educational intervention completed the module and the NMD-CEX. Residents scored >80% on the CEX for desired patient-care behaviors across all domains of physical examination, including communication. Residents scored best on ability to conduct a systematic examination, showing respect, and being sensitive to the patient (>94%); they scored lower in their abilities to communicate during the physical exam (87%), to adapt to specific needs of the patient (80%), and to accurately detect abnormal findings (87%). | Good/#4748/ Learning in a Web-Based World: An Innovative Approach to Teach Physical Examination Skills in Patients with Neurodisability |
| Alsaid (2016) | Interventional, comparative sudy | eLearning, graphic tablet | 2 | Neuroanatomy | 65 2nd year medical students | Graphic tablet group vs. PPT group | Full Text | *Morphologie* | Students were evaluated three times: before the lecture, immediately after the lecture and 8 weeks later. Means were compared using a t-test. | Scores were significantly higher immediately after the lecture and 8 weeks later tests in comparing the transverse section (using the graphics tablet) versus the sagittal section (using PowerPoint®). Student satisfaction regarding the use of the tablet was high. | Good/#704/ Slide shows vs graphic tablet live drawing for anatomy teaching |
| Bensalem-Owen, et al. (2011) | Interventional study | eLearning, podcast | 2 | Clinical Neurology, EEG | 10 physicians | Data compared to previous scores from traditional didactic training from previous study | Full Text | *Neurology* | Using 25-question evaluation tools, participants were assessed at baseline before any EEG instruction, and reassessed after podcasting and after 10 clinical EEG exposures. Each 25-item evaluation tool contained tracings used for clinical EEG interpretations. Scores after podcast training were also compared to scores after traditional didactic training from a previous study among anesthesiology trainees. | The mean scores with standard deviations are 9.50 2.92 at baseline, 13.40 3.31 (p 0.034) after the podcast, and 16.20 1.87 (p 0.019) after interpreting 10 EEGs. No differences were noted between the mean educational tool scores for those who underwent podcasting training compared to those who had undergone traditional didactic training. | Good/#64/Education Research: Evaluating the use of podcasting for residents during EEG instruction A pilot study. |
| **Yadala, et al. (2020)** | **Interventional study** | **eLearning, Zoom platform** | **2** | **Clinical Neurology, EEG** | **11 neurology residents** | **No comparison group** | **Full Text** | ***Cureus*** | **Residents participated in live, interactive virtual sessions for eight weeks. A pre-test and post-test were administered, and a survey was performed at the end of the project.** | **There was a significant improvement on average resident test scores. On the survey, 100% agreed (81.8% strongly agreed, 18.2% agreed) that virtual EEG sessions provided a conducive learning environment with easy access while preserving effective communication with the instructor. When compared to traditional EEG reading, 100% agreed (81.8% strongly agreed and 18.2% agreed) that virtual sessions were more accessible, 72.7% agreed (54.5% strongly agreed, 18.2% agreed) that they were more interactive; 81.9% (45.5% strongly agreed, 36.4% agreed) felt more engaged and 90.9% agreed (81.8% strongly agreed, 9.1% agreed) that they were able to attend more sessions. Hundred percent residents (72.7% strongly agreed, 27.3% agreed) felt more confident in their EEG reading and all (81.8% strongly agreed and 18.2% agreed) would sign up for more virtual learning courses.** | **Good/#2966/ Resident Education During COVID-19 Pandemic: Effectiveness of Virtual Electroencephalogram Learning.** |
| Pannell, et al. (2016) | Interventional study | Simulation | 2 | Neuroradiology | 5 participants, 1 medical student, 2 neuroradiology fellows | No comparision group | Full Text | *Cureus* | neurointerventional evaluated: Total procedure time, fluoroscopy time, contrast dose, heart rates, blood pressures, medications administered, packing densities, the number of coils used, and the number of stent-retriever passe | all participants demonstrated marked decreases in procedure time, fluoroscopy doses, contrast doses, and adverse technical events; marked improvements in image quality, device selection, access scores, and overall technical performance were additionally observed (p < 0.05). Similarly, trainees demonstrated marked improvement in technical performance and clinical management after five coiling procedures (p < 0.05). | Good/#3272/ Simulator-Based Angiography and Endovascular Neurosurgery Curriculum: A Longitudinal Evaluation of Performance Following Simulator-Based Angiography Training. |
| OrtizGarcia, et al. (2016) | Interventional study | Simulation | 2 | Clinical Neurology, Brain death | Neurology residents, 18 | No comparison group | Full Text | *Neurology* | The 2-hour postintervention assessment repeated the brain death examination and family discussion simulations. | A total of 18 residents (100%) were assessed, with significant differences between preintervention and postintervention testing across all areas, including clinical assessment (45%–76%, P , .001), apnea testing (57%–92%, P , .001), and verbal communication (46%–73%, P , .001). | Strong/#1376/ Simulation-based training in brain death determination incorporating family discussion: A pilot project |
| Haque, et al. (2017) | Interventional, feasibility study | Simulation | 2 | Neurological emergencies | 19 physicians, 171 residents, | No comparison group | Full Text | *Pediatric Emergency Care* | At the end of course, all participants were requested to give feedback on a structured evaluation form of the course on a 5-point Likert scale from 1 (lowest) to 5 (highest). The contents were objective of the course, application to clinical practice, emphasis on key points, knowledge enhancement, and facilitators teaching performance. | Eleven courses were conducted during the study period. One hundred ninety-six physicians including 19 consultants and 171 residents participated in these courses. The mean (SD) score was 65.15 (13.87%). Seventy percent (132) of participants were passed (passing score > 60%). The overall satisfaction rate was 85%. | Good/#1088/ Development of Pediatric Neurologic Emergency Life Support Course. |
| Jost, et al. (2017) | Static group comparison design | Team based learning (TBL) | 2 | Clinical Neurology | 26 medical students (15 control, 11 treatment group) | Treatment group (TBL) vs control (usual lecture format) | Full Text | *BMC Res Notes* | Clinical decision making skills were assessed using a key-feature problem examination. Factual and conceptual knowledge was assessed by a multiple-choice question examination. | The TBL-group performed significantly better than the non-TBL-group (p = 0.026) in the key-feature problem examination. No significant differences between the results of the multiple-choice question examination of both groups were found. | Good/#3581/ Effects of additional team-based learning on students' clinical reasoning skills: a pilot study. |
| De Faria, et al. (2016) | Interventional, comparative study | VR | 2 | Neuroanatomy | 84 medical students | Group 1 conventional methods, Group 2 interactive nonstereoscopic learning methods, Group 3 interactive stereoscopic lectures | Full Text | *Journal of Neurosurgery* | Pretest evaluation, | Groups 2 and 3 showed the highest mean scores in pedagogic evaluations and differed significantly from Group 1 (p < 0.05). Size effects, measured as differences in scores before and after lectures, indicate the effectiveness of the method. | Strong/#685/ Virtual and stereoscopic anatomy: When virtual reality meets medical education |
| Dardick, et al. (2019) | Interventional study | VR (virtual reality training) - Simbionix Mentor Flex | 2 | Neuroradiology | 7 trainees (medical students, neuroradiology, neurosurgery residents) | No comparison group | Full Text | *Surgical Neurology International* | Intervention completion times | Trainees significantly improved their time to every procedural benchmark during their second MCA revascularization (mean decrease = 1.08, 1.57, and 2.24 min; P = 0.0072, 0.0466, and 0.0230). In addition, time required to access the LICA during aneurysm coiling was shortened by 0.77 min for each previous VR right MCA revascularization performed (P = 0.0176; r2 = 0.71). Finally, medical students’ MCA revascularization simulation times improved by 0.87 min for each prior simulation viewed (P < 0.0221; r2 = 0.96) | Good/#3283/ Virtual reality simulation of neuroendovascular intervention improves procedure speed in a cohort of trainees. |
| Dingle, et al. (2019) | Interventional Study | PBL, eLearning | 2 | Clinical Neurology | Medical students | No comparison group | Full Text | *Acad. Psychiatry* | The SOM evaluation and assessment team evaluates faculty and courses through frequent focus groups and surveys with selected students; by the end of each course, all students participate | Quantitative outcomes were outstanding by intrinsic (passing rates) and extrinsic (bench exams performance) measures. Mid module examination was compared with NBME final demonstrating a correlation of R = 0.73 (p < 0.001), suggesting that the course content aligned well with national standards. All students passed the course without curving the scores. | Good/#3478/ Mind, Brain, and Behavior: an Integrative Approach to Teaching Neuroscience to Medical Students. |
| Alimoglu, et al. (2017) | Interventional and comparative study | Team based learning (TBL) | 2 | Clinical Neurology, polyneuropathies | 179 medical students | TBL vs lecture group | Full Text | *Adv. Physiol Educ* | First, determined in-class engagement and satisfaction of the students for the lectures given in the 2013–2014 academic year. The following year, besides the same criteria, we also determined individual (IRAT) and group readiness test (GRAT) scores in the TBL group. End-of-clerkship exam scores for both groups were recorded. | We found no difference between groups regarding end-of-clerkship exam scores. The mean knowledge retention test score of the TBL group was significantly higher than that of the lecture group (5.85 1.74 vs. 3.28 1.70). The differences between IRAT, GRAT, and retention test scores in the TBL group were significant. The mean student satisfaction score on a five-point scale was 3.01 0.9 (median 3) in the lecture group and 4.11 1.1 (median 4) in the TBL group. | Good/#3795/ The effectiveness of TBL with real patients in neurology education in terms of knowledge retention, in-class engagement, and learner reactions. |
| Nowinski, et al. (2013) | Exploratory, feasibility, overview study | 3-D modeling/printing | 1 | Clinical Neurology | N/A | No comparison group | Full Text | *Neuroradiology Journal* | Three-dimensional (3D) interactive atlas of neurological disorders providing the correspondence between a brain lesion and the resulting disorder(s). The atlas contains a 3D highly parcellated atlas of normal neuroanatomy along with a brain pathology database. | Potentially useful to a wide variety of users ranging from medical students, residents and nurses to general practitioners, neuroanatomists, neuroradiologists and neurologists, as it contains both normal (surface and sectional) brain anatomy and pathology correlated with neurological disorders presented in a visual and interactive way. | Good/#1294/ Bridging neuroanatomy, neuroradiology and neurology: Three-dimensional interactive atlas of neurological disorders. |
| Ruisoto, et al. (2014) | Interventional, feasibility study | 3-D modeling/printing | 1 | Neuroanatomy | 65 medical students | No comparison group | Full Text | *Computer Human Behavior* | Participants were asked to anonymously complete an online rating-scale to measure the educational value that they assigned to the viewer after exploring it for 10 min individually. Participants completed a computerized version of the Surface Development Test to measure their visuospatial ability. The task consisted of an association between letters on a concrete surface in a three-dimensional figure and between numbers in a two-dimensional geometric image corresponding with the development of its surface. This test contained 12 items and the maximum completion time was 14 min. | Showed a profound and positive impact on how students feel about this tool in neuroanatomy learning. Students with high visuospatial ability (M = 23.42 ± 2.29) and low visuospatial ability (M = 19.23 ± 3.76) showed no significant differences in the high educational value assigned to this tool for learning spatial relationships (items 1 and 3) and facilitating functional image interpretation (items 2 and 4). | Good/#5040/ Enhancing neuroanatomy education using computer-based instructional material. |
| Bannon, et al. (2020) | Interventional, instructional study, feasibility study | 3-D modeling/printing | 1 | Neuroanatomy  | N/A | No comparison group | Full text | *Surgical and Radiologic Anatomy* | Used open-source software to create a volume render of the pterygopalatine fossa from axial slices of a head computerized tomography scan. These data were then exported to a 3D printer to produce an anatomically accurate model. | The resulting ‘negative space’ model of the pterygopalatine fossa provides a useful and innovative aid for understanding the complex anatomical relationships of the pterygopalatine fossa. | Good/#1168/3D printing the pterygopalatine fossa: a negative space model of a complex structure. |
| Dixit, et al. (2018) | Interventional, observational study | 3-D modeling/printing | 1 | Neuroanatomy | 1st year medical students | No comparison group | Full Text | *Journal of Clinical Neuroscience* | Participants were divided into 8 groups and each was allotted a specific activity related to a particular cross-sectional level and allowed to build with the material provided by the department. Student feedback was taken through a structured questionnaire. | 81 and 82.4% of students stated that the activity was clearly explained and should be offered more frequently in curriculum. The activity also developed a positive attitude and good coordination amongst peers with increase in communication skills (89.1%, 91.8%, 89% respectively). 87.8% of students agreed that small group learning is better than didactic lectures in neuroanatomy. | Good/#1505/ Low fidelity model making activity by students: A novel way of learning concepts of neuroanatomy. |
| Nowinski, et al. (2013) | Exploratory study | 3-D modeling/printing  | 1 | Neuroanatomy | N/A | No comparison group | Full Text | *Neuroradiology Journal* | The CN pathology database was populated with 36 lesions compiled from clinical textbooks. The initial view of each disorder was preset in terms of lesion location and size, surrounding surface and sectional neuroanatomy, and disorder and neuroanatomy labeling. | This atlas of CN-related disorders is potentially useful to a wide variety of users ranging from medical students and residents to general practitioners, neuroradiologists and neurologists, as it contains both normal brain anatomy and CN-related pathology correlated with neurological disorders presented in a visual and interactive way. | Good/#1293/ Three-dimensional interactive atlas of cranial nerve-related disorders. |
| Gheysens, et al. (2017) | Interventional study | Art education, drawing | 1 | Neuroanatomy | Medical students | No comparison group | Full Text | *MedEdPORTAL : the journal of teaching and learning resources*  | The materials associated with the module include an answer packet to use as a guide through the module cases, and both pre- and postmodule practice questions for self-evaluation. Both modules were tested at our institution by separate groups of second-year medical students in the early portion of their neuroanatomy course | Both module versions showed significant improvement in confidence levels when describing spinal cord anatomy and lesion localization. Furthermore, students were highly satisfied with the material and reported they were likely to reuse it for additional studying | Good/#1026/ Teaching Spinal Cord Neuroanatomy through Drawing: An Interactive, Step-Wise Module. |
| Harrison, et al. (2019) | Interventional, feasibility study | Art-based education | 1 | Clinical Neurology | 18 neurology residents | No comparison group | Full Text | *Neurology* | Anonymous evaluation using a 5-point Likert scale to rate course effectiveness and perform a retrospective pre- and post-self assessment of communication and visual observation skills. | All participants rated the course highly and found the exercises effective in enhancing awareness of language and observational skills. Eighty percent of participants rated their listening and observation skills as above average after participation, which improved from 63% and 45%, respectively, before the sessions. | Good/#1564/ Education Research: An arts-based curriculum for neurology residents. |
| Garcin, et al. (2019) | Interventional study | Gaming | 1 | Clinical Neurology | 112 2nd year medical students | No comparison group | Full Text | *Revue Neurologique* | To assess the efficacy of this learning procedure, multiple choices questions (MCQs) were asked before and after the game. Exam results of second-year students on their final university Neurology exam were analyzed. A satisfaction survey was proposed to all participating students. | Among 373 students, 121 volunteers (32.4%) were enrolled in the ‘‘Neurology Hat Game’’ and 112 attended the game. One hundred and seven of the 112 students completed the MCQs with a significant improvement in their responses after the game (P < 0.001). The 112 students who completed the satisfaction self-administered questionnaire were very satisfied with this funny new teaching method. | Good/#1828/ The “Neurological Hat Game”: A fun way to learn the neurological semiology |
| Patel, et al. (2019) | Interventional study | Simulation | 1 | Neurological emergencies, Neuromuscular weakness | 14 neurology residents | No comparison group | Full Text | *Journal of teaching and learning resources* | The simulation scenario is followed by a facilitated debriefing session. Details about the simulation scenario, critical action checklist, environment preparation, actors/roles, and debriefing session are outlined | A postsimulation survey revealed that participants thought the simulation achieved its stated objectives, was useful, and would impact their future practice. | Good/#1565/ Acute Neuromuscular Respiratory Weakness Due to Acute Inflammatory Demyelinating Polyneuropathy (AIDP): A Simulation Scenario for Neurology Providers. |
| Lewis, et al. (2018) | Interventional study | Simulation | 1 | Clinical Neurology, Brain death | Medical students | No comparison group | Full Text | *Clinical Neurology and Neurosurgery* | Students attended a 90-min brain death didactic and simulation session during their neurology clerkship. Students completed a test immediately before and after participating in the initiative. | Students correctly answered a median of 53% of questions (IQR 47–58%) on the pretest and 86% of questions (IQR 78–89%) on the posttest (p < .001). Comfort with both performing a brain death evaluation and talking to a family about brain death improved significantly after this initiative (18% of students were comfortable performing a brain death evaluation before the initiative and 86% were comfortable doing so after the initiative, p < .001; 18% were comfortable talking to a family about brain death before the initiative and 76% were comfortable doing so after the initiative, p < .001). | Good/#1475/ An educational initiative to improve medical student awareness about brain death. |
| Roze, et al. (2016) | Interventional study | Simulation | 1 | Clinical Neurology | 3rd year medical students | No comparison group | Full Text | *Revue Neurologique* | Using an anonymous self-administered questionnaire, the students’ and teachers’ emotional experience and views on the impact of the program were then investigated | A total of 223/365 students (61%) chose to participate in the study.Both students and teachers felt their participation was pleasant. Students stated that The Move increased their motivation to learn neurological semiology (78%), and improved both their understanding of the subject (77%) and their long-term memorization of the teaching content (86%). Although only a minority thought The Move was likely to improve their performance on their final medical examination (32%), a clear majority (77%) thought it would be useful for their future clinical practice. Both students (87%) and teachers (95%) thought The Move should be included in the medical curriculum. | Good/#1369/'The Move', an innovative simulation-based medical education program using roleplay to teach neurological semiology: Students' and teachers' perceptions. |
| Shiels, et al. (2017) | Longitudinal, investigational study | Team Based Learning (TBL) | 1 | Neurophobia | 446 M1, 206 M2 medical students | Comparisons of TBL, case-based teaching (CBT), and problem-based learning (PBL) | Full Text | *BMC medical education* | Three neuroscience educational interventions were studied: team-based learning (TBL), case based teaching (CBT), and problem-based learning (PBL). Participants provided self-reported neurophobia levels, attitudes about neuroscience, and the effectiveness of educational intervention. | A significant change in self-reported neurophobia (p = 0.035) was observed from 19% in M1 to 26% in M2. Neuroscience knowledge and confidence managing a neurologic condition also significantly increased (p < 0.001 and p = 0.038 respectively). Perceived interest, difficulty, and desire to pursue a career in neuroscience did not a change significantly. Majority of students perceived CBT (76%), TBL (56%), and PBL (66%) beneficial. Only CBT demonstrated a statistical difference (p = 0.026) when stratified by self-reported change in neurophobia. | Good/#1091/ Medical student attitudes and educational interventions to prevent neurophobia: a longitudinal study |
| Li, et al. (2014) | Interventional study | eLearning | 0 | Neuroanatomy | N/A | No comparison group | Full Text | *The Journal of Craniofacial surgery* | Developed a digital interactive human brain atlas based on the Chinese visible human datasets for anatomy teaching | It is potentially useful for anatomy browsing, user self-testing, and automatic student assessment. In a word, it is interactive, 3D, user friendly, and free of charge, which can provide a new, intuitive means for anatomy teaching. | Good/#818/ A digital interactive human brain atlas based on Chinese visible human datasets for anatomy teaching. |
| Manson, et al. (2015) | Feasibility study, methodology | eLearning, Computer based 3-D modeling | 0 | Neuroanatomy | N/A | No comparison group | Full Text | *BMC Med* | N/A | successfully created a robust methodology by using key software packages in the creation of an interactive education and training tool., which details the anatomy of the ventricular system, and flow of cerebrospinal fluid using an anatomically accurate 3D model. In addition to this, our established workflow pattern presented here also shows how tutorials, animations and self-assessment tools can also be embedded into the training application | Good/#4504/ A recommended workflow methodology in the creation of an educational and training application incorporating a digital reconstruction of the cerebral ventricular system and cerebrospinal fluid circulation to aid anatomical understanding |
| Greuter, et al. (2021)  | Randomized, Investigational, comparative study   | VR  | 2 | Neuroradiology   | Medical students   | 3-D VR group vs 2-D images group   | Full Text   | *Neurosurgical Focus*  | The time to aneurysm detection as well as a spatial anatomical description was assessed via an online questionnaire and compared between the groups.  | Overall, the time to aneurysm detection was shorter in the 3D VR model compared to 2D images, with a trend toward statistical significance (25.77 ± 37.26 vs 45.70 ± 51.94 seconds, p = 0.052). No significant difference was observed for residents (3D VR 24.47 ± 40.16 vs 2D 33.52 ± 56.06 seconds, p = 0.564), while in students a significantly shorter time to aneurysm detection was measured using 3D VR models (26.95 ± 35.39 vs 59.16 ± 44.60 seconds, p = 0.015). No significant differences between the modalities for anatomical and descriptive spatial mistakes were observed. Most participants (90%) preferred the 3D VR models for aneurysm detection and description, and only 1 participant (5%) described VR-related side effects such as dizziness or nausea.  | Good/#5625/ Randomized study comparing 3D virtual reality and conventional 2D on-screen teaching of cerebrovascular anatomy.  |
| John, et al. (2021)   | Comparison study  | eLearning   | 1 | Neuroanatomy   | 72 medical students   | No comparison group   | Full Text   | *National Journalof Clinical Anatomy*  | Online live streamed classes using Free Conference Call app were held in the Department of Anatomy, AIIMS Raipur. Live streaming, pre-recorded lecture videos were supplemented by cadaveric dissection videos, assignments etc posted in Google Classroom. Feedback regarding the online classes were obtained from first year undergraduate medical students using Google Forms.   | 57 students used mobile phones to access the classes. 10 students preferred the online classes with chalk and board lecture, 23 students preferred lecture with PowerPoint presentation while the rest preferred online classes with chalk and board lecture followed by PowerPoint presentation. Out of the total (n=72) respondents, majority of them experienced technical issues which hampered their online learning experience. Owing to this reason, 43 students showed preference for prerecorded videos over online live classes. 41.7% of the students opined that online classes should be included as a part of MBBS anatomy curriculum. C  | Good/#6288/ A study on the advantages and disadvantages of the online teaching program conducted in the Department of Anatomy, AIIMS, Raipur – students’ perspective.  |
| McAllister, et al. (2021)  | Investigational, interventional, feasibility study   | Flipped classroom   | 1 | Clinical Neurology   | 80 1st year medical students   | No comparison group   | Full Text   | *MedEdPORTAL: The journal of teaching and learning resources*  | The second-year students designed a series of board-style questions that included explanations for both the correct and incorrect answers. We divided the first-year students (n = 80) into small groups during the flipped classroom sessions, where they were led by second-year medical students in discussion about the questions and clinical situations  | Students reported agreement that the session addressed gaps in their knowledge and provided them with useful critical thinking skills for approaching board-style questions (83% and 81% agreed or strongly agreed, respectively).  | Good/#5728/ Neuroscience Near-Peer-Led Flipped Classroom Improves Student Confidence With Clinical Application of Content and Test-Taking Skills.  |
| Afif, et al. (2021)   | Investigational, interventional study   | Role play   | 1 | Clinical Neurology, brain death   | 1422 residents   | No comparison groups   | Full Text   | *Journal of Surgical Education*  | 1389 (97.7%) participants competed the pre-intervention survey, while 1361 (95.7%) completed the postintervention survey.  |  Prior to the training, only 56% of residents correctly identified BD/DNC as synonymous with death. Additionally, 40% of residents had explained BD/DNC to families at least once, but 41% of residents reported never having been taught how to do so. The biggest fear reported in discussing BD/DNC with families was being uncomfortable in explaining BD/DNC (48%). After participating in the training, 99% of residents understood the definition of BD/DNC and 92% of residents felt comfortable discussing BD/DNC with families.  | Good/#5807/ Formal Training Improves Resident Understanding and Communication Regarding Brain Death/Death by Neurologic Criteria.  |
| Ream, et al. (2021)   | Investigational study   | Simulation   | 1 | Clinical Neurology   | 16 neurology trainees   | No comparison group   | Full Text   | *MedEdPORTAL: the journal of teaching and learning resources*  | Used a modified Gap-Kalamazoo Communication Skills Assessment Form to assess communication skills. The assessment was completed by faculty, SPs, and the resident, and we measured agreement among raters. Residents were surveyed afterward regarding their experience. R  | Nine cases were developed and piloted. A total of 27 unique resident-case encounters with 16 individual trainees occurred over three annual implementations. Scores on the 360-degree assessment of communication skills showed that residents overwhelmingly underassessed their skills compared to other rater groups. Among 18 responses on the post-OSCE survey, the majority (77%) found the experience useful to their education and felt that the feedback from the SPs was helpful (61%) and the case portrayals were realistic (89%).  | Good/#5731/ Improving Child Neurology Residents' Communication Skills Through Objective Structured Clinical Exams.  |
| Munawar, et al. (2021)   | Investigational study   | Social Media, Reddit   | 1 | Neuroradiology   | N/A  | N/A  | Full Text   | *Current Problems in Diagnostic Radiology*  | Two subreddits were reviewed: r/radiology (top 100 posts) and r/medicine (search queries: radiology, x-ray, CT scan, MRI, ultrasound, PET scan, and mammogram). Post aims and user types were categorized. Kruskal-Wallis H and post-hoc pairwise Mann-Whitney U tests were performed to assess user and post types associated with greater post comments and points  | A total of 323 posts submitted by 258 unique users over a 9 year period with a median of 21 comments (range 0-568) and 119 points (0-1877) were reviewed. These were most commonly posted by physicians (41%), radiologic technologists (18%), and medical students (12%). Radiologists represented 30% of physicians and 12% of all users. Posts by physicians had significantly higher median comments and points than half of other user categories (P = <0.01-0.04). Most posts related to imaging case presentations (25%), comedic content (18%), and imaging appropriateness (10%). The most common radiology subspecialties featured were musculoskeletal (26%), neuroradiology (22%), abdominal (21%), and cardiothoracic (20%). Although only 1% of posts featured wellness and burnout, they had significantly higher median comments and points than 14 of 15 and 15 of 15 other post categories, respectively (P = <0.01-0.03).  | Good/#5678/ Radiology on Reddit: A Content Analysis and Opportunity for Radiologist Engagement and Education.  |
| Shahmoradi, et al. (2020)   | Interventional study   | VR   | 1 | Clinical Neurology   | 31 medical students   | No comparison group   | Full Text   | *Journal of Education Health Promotion*  | The opinions of 31 undergraduate students about the teaching session were evaluated by two anonymous questionnaires.  | The evaluation showed that the median score for students’ perception of learning was 3.11. The median scores of questions related to the “facilitating level of virtual reality” and “student satisfaction” were 8.66 and 9, respectively. The analysis of students’ responses to open‑ended questions highlighted the therapeutic aspect of the game compared to its educational aspect.  | Good/#6141/ Learning promotion of physiotherapy in neurological diseases: Design and application of a virtual reality-based game.  |
| Newman, et al. (2021)   | Survey   | 3-D modeling, eLearning, etc.   | 0 | Neuroanatomy   | N/A  | N/A  | Full Text   | *World Neurosurgery*  | An electronic survey was sent to Australian (n [ 22) and New Zealand (n [ 2) medical schools, endorsed by the Royal Australasian College of Surgeons. Academics were asked to comment on the course, content, instruction, and assessment of neuroanatomy for the 2019 academic year.   | Ninety-two percent (22/24) of medical schools responded. Neuroanatomy content and instructional methodology was highly variable between institutions. The average time dedicated to teaching neuroanatomy was 46.0 hours (38.1) with a range of 12e160 hours. Prosections (77%) and models (77%) were used at most universities. Dissection was utilized at 13 of 22 (59%) universities. Incorporation of new technologies was highly variable, the most common being 3-dimensional software (59%) and eBook (55%). Adoption of any virtual reality technologies was low (36%). Seven universities used an established curriculum (29%), whereas most did not (61%). Academics indicated anxiety and motivation were key elements of student engagement.  | Good/#5679/ Neuroanatomy Teaching in Australian and New Zealand Medical Schools.  |
| Lopez, et al. (2021)   | Investigational, interventional study   | VR   | 2 | Neuroanatomy   | 120 medical students   | control (traditional class) vs VR group   | Full Text  | *Computer Electrical Engineering*  | part of two groups: the control group participated in a traditional class, experimental in a virtual reality session. Their performance was cataloged in: 1-insufficient, 2-under development, and 3-competent  | A significant difference was found as the control group obtained a mean of 1.63, while the experimental 2.28. Students who used virtual reality seem to demonstrate better performance in identifying structures and describing the functional implications.  | Good/#6392/ Virtual reality vs traditional education: Is there any advantage in human neuroanatomy teaching?  |
| Bolek, et al. (2021)   | Investigational study   | VR/AR  | 1 | Neuroanatomy   | 222 medical students   | No comparison group   | Full Text  | *Anatomical Sciences Education*  | Students filled out the Instructional Measure of Motivation Survey (IMMS), directly after their learning session in the dissection rooms. The IMMS was designed to measure the four motivational goals for learning.  | Motivation elicited by the GreyMapp-AR, an AR application, was investigated in medical and biomedical sciences students (n = 222; mean age: 19.7 ±1.4 years) using the Instructional Measure of Motivation Survey (IMMS). Additional components (i.e., attention, relevance, confidence, and satisfaction) were also evaluated with motivation as measured by IMMS. Additionally, 19 students underwent audio-recorded individual interviews which were transcribed for qualitative analysis. Males regarded the relevance of AR significantly higher than females (P < 0.024). Appreciation of the GreyMapp-AR program was found to be significantly higher in students studying biomedical sciences as compared to students studying medicine (P < 0.011). Other components and scores did not show significant differences between student groups.  | Good/#5633/ Mixed-methods exploration of students' motivation in using augmented reality in neuroanatomy education with prosected specimens.  |
| Drapkin, et al. (2015) | Interventional Study | eLearning | 2 | Neuroradiology | Medical students | 3-D MRI tool vs traditional group | Full text | *Anatomical sciences education* | The efficacy of this tool was assessed by comparing scores from an MRI identification quiz and survey in two groups. | Students from the experimental group performed marginally better than the control group on overall test score (P 5 0.07) and significantly better on test scores extracted from questions involving C-shaped internal brain structures (P< 0.01). Experimental participants also expressed higher confidence in their abilities to visualize the 3D structure of the brain (P 5 0.02) after using this tool. Furthermore, when surveyed, 100% of the students in the experimental group recommended this tool for future students. | Good/#571/ Development and assessment of a new 3D neuroanatomy teaching tool for MRI training |
| Vasilopoulos, et al. (2015) | Interventional study | eLearning, Podcast | 2 | Clinical Neurology, EEG | Anesthesiology residents, 4th year medical students | Intervention group vs. Control group | Full Text | *Anesthesia and Analgesia* | Multiple analyses were performed (1) to evaluate differences in improvement in EEG evaluation scores between the podcast module and the standard didactics (control group); and (2) to evaluate potential moderation by technology and the podcast experience on the change in mean EEG evaluation scores from after the podcast module to after 10 EEG interpretations. | : A total of 21 anesthesiology residents and 12 fourth-year medical students participated. Scores on the 25-item evaluation tool increased with each evaluation time (P ≤ 0.001). Moderation analyses revealed that individuals with more podcast experience (≥4 previous podcasts) had greater increases in scores after a podcast and 10 EEG interpretations compared with individuals with less experience (≤3 previous podcasts) (P = 0.027). Furthermore, compared with a control group with similar baseline characteristics that received only standard didactics without a podcast, those in the podcast group had greater increases in mean EEG evaluation scores between baseline and after 10 EEG interpretations. | Good/#284/ Prior podcast experience moderates efficacy of electroencephalography. |
| Whillier, et al. (2015) | Comparative study | Flipped classroom | 2 | Neuroanatomy | 60 2nd year medical students | Flipped classroo (2013) participants vs 2011 traditional cohort | Full Text | *Journal of Chiropractic Education* | Final course grades overall and participant satisfaction. | There were no significant differences between the 2 cohorts in final grades (p=.259), self-rated knowledge (p= .182), or overall satisfaction with the course (p= .892). | Good/#2898/ No differences in grades or level of satisfaction in a flipped classroom for neuroanatomy |
| Braksick, et al. (2017) | Interventional study | Simulation | 2 | Neurological emergencies | 16 neurocritical care trainees | No comparison group | Full Text | *Neurocritical care* | Pre- and posttests assessing medical knowledge and trainee confidence in managing neurologic disease were completed by all trainees. Overall satisfaction and effectiveness were evaluated following the course. Change in trainee knowledge and confidence before after the course was assessed for improvement. | Medical knowledge was 5.2 ± 0.9 (of 8 possible correct answers) and following the course was 6.4 ± 1.3 (p = 0.002). Overall confidence improved from 15.4 ± 4.9 (of 30 possible points) to 20.7 ± 3.3 (p = <0.0001). Confidence was significantly improved for neurologic diseases directly assessed during the course (p = <0.0001) as well as for those not directly assessed (p = 0.004). | Strong/#753/ Neurology Education for Critical Care Fellows Using High-Fidelity Simulation. |
| McMillan, et al. (2016) | Interventional study | Simulation | 2 | Clinical Neurology, Lumbar puncture | 20 pediatric residents | No comparison group | Full Text | *BMC medical education* | Residents were asked to report their post-graduate year (PGY), prior LP attempts and self-reported anxiety scores. Then completed an observed pre-test using an infant-sized LP simulator. Staff physicians observed and scored each resident’s procedural skill using a previously published 21-point scoring system. Repeat post-test was performed within 4 months. | 16/20 (80 %) completed both the training session and post-test. Their PGY training level was: PGY1 (38 %), PGY2 (25 %), PGY3 (25 %) or PGY4 (12 %). Procedural skill improved in 15/16 residents (paired t-test; p < 0.001), driven by a significant improvement in skill for residents in PGY1 (P = 0.015) and PGY2 (p = 0.003) but not PGY3 or PGY4. Overall anxiety scores were higher at baseline than at post testing (mean ± SD; 44.8 ± 12.1 vs 39.7 ± 9.4; NS) however only PGY1 residents experienced a significant reduction in anxiety (paired t-test, p = 0.04). | Good/#646/ Lumbar puncture simulation in pediatric residency training: improving procedural competence and decreasing anxiety. |
| Mikhaeil-Demoa, et al. (2020) | Interventional Study, pilot | Simulation | 2 | Neurological emergencies, Status epilepticus | PGY-2 Neurology residents | No comparison group | Full Text | *Epilepsy and Behavior* | Compared pretest with posttest simulated SE skills performance and posttest with reassessment in situ performance. | The MPS was set at 88% (23/26) checklist items correct. Sixteen neurology residents participated in the intervention. Participant performance improved from a median of 44.23% (Interquartile range (IQR): 34.62– 55.77) at pretest to 94.23% (IQR: 92.13–100) at the posttest after SBML (p < .001). There was no significant difference in scores between the posttest and in situ test up to 8 months later (94.23%; IQR: 92.31–100 vs. 92.31%; IQR: 88.46–96.15; p = .13) | GStrong/#2161/ Use of a simulation-based mastery learning curriculum for neurology residents to improve the identification and management of status epilepticus. |
| Musacchio, et al. (2010) | Interventional, pilot study | Simulation | 2 | Neurological Emergencies | 29 participants (medical students, neurology residents), general surgery residents) | No comparison group | Full text | *Neurocritical Care* | A three-way evaluation model was employed to test validity, including pre- and post-exercise testing, survey feedback, and videotaped replay. | On a 20-point critical care multiple-choice exam for these participants, average improvement has been 4.5 points or 25%. In subgroup analysis, average improvement was 4.75 points (24%) amongst neurosurgery residents, 3.07 points (18%) amongst neurology residents, 7 points (38%) amongst general surgery residents, and 7 points (38%) amongst senior medical students. Post-exercise evaluations were overwhelmingly positive | Strong/522/ Neuro-critical care skills training using a human patient simulator |
| Spiotta, et al. (2013) | Interventional study | Simulation | 2 | Neuroradiology | 4 neuroIR fellows | No comparison groups | Full Text | *Journal of NeuroInterventional Surgery* | Participants were instructed to catheterize the right internal carotid artery, left internal carotid artery and left vertebral artery. The task was repeated five times. | All participants demonstrated improvement over the five trials. Residents performed actions that were perceived as potentially dangerous (n=8) while fellows performed the procedure with superior technique. Residents performed the task with an initial total procedure and fluoroscopy time of 6.664.3 min and 4.963.7 min, respectively, and improved on the fifth trial to 3.461.3 min (p<0.03) and 2.360.78 min (p<0.004), respectively. Residents approximated the efficiency of fellows for the third and fourth trial. | Good/#54/ Simulated diagnostic cerebral angiography in neurosurgical training: A pilot program. |
| Brich (2013) | Interventional, comparative study | Team based learning | 2 | Clinical Neurology | 35 3rd year medical students | Participants vs non-participants | Full Text | *GMS Z Med Ausbild* | Pretest (i-RAT, t-RAT), posttest | The group of TBL participants achieved a significantly higher overall point total (33.7 vs. 32.5 points; p= 0.016) in comparison to the group which did not participate in the voluntary TBL course. For the pool of questions on the non-TBL topics, there is no significant difference between the two groups (20. 7 vs. 20.3; p= 0.358), while for the question pool dealing with the TBL topics, a significantly better result can be seen for the TBL participants (13.0 vs. 12.2 points; p= 0.006). | Good/#3791/ Feasibility, acceptance and impact of team-based learning in neurology: a pilot study. |
| Yang, et al. (2014) | Randomized, Interventional and comparative study | Team based learning (TBL) | 2 | Clinical Neurology | 127 4th year medical students | Group A (TBL + LBL (lecture based learning), with 41 students), Group B (LBL, with 43 students), and Group C (TBL, with 43 students) | Full Text | *BMC Medical Education* | Questionnaire, 2 tests after completion of 2 week course: theoretical/practice test | practice test scores of Group A (TBL+LBL) were similar to those of Group B, but significantly higher than those of Group C. The theoretical test scores and the total scores of Group A were significantly higher than those of Groups B and C. In addition, 100% of the students in Group A were satisfied with the combination of TBL + LBL. | Strong/#2312/ Evaluating team-based, lecture-based, and hybrid learning methods for neurology clerkship in China: a method-comparison study. |
| Ochoa, et al. (2012) | Interventional study | VR | 2 | Clinical Neurology, EEG | Community boarded neurologists | 20 neurologists | Full text | *Teaching and learning in medicine* | A 40-question pretest exam was 15 performed before training. The training included 4 online learning units about basic EEG principles and 40 online clinical EEG tutorials. In addition there were weekly live teleconferences for Q&A sessions. At the end of the program, the participants were asked to complete a posttest exam | Fifteen of 20 participants successfully completed the program and took both the preand posttest exams. All the subjects scored significantly higher in the posttest compared to their baseline score. The average score in the pretest evaluation was 61.7% and the posttest average was 87.8% (p = .0002, two-tailed). | Good/#109/ Using a virtual training program to train community neurologist on EEG reading skills. |
| Memon, et al. (2016) | Interventional study | Flipped classroom | 1 | Neuroanatomy | 2nd year medical students | 340 medical stduents | Full text | *Journal of Postgraduate Medical Institute* | Students’ perceptions were assessed by asking them to fill questionnaires. The post unit test was conducted to evaluate the effectiveness of this method. | Ninety-six percent of students believed that the flipped classroom approach was better in targeting learning objectives than the conventional teaching, 95% thought that the work-sheet with questions provided before class enabled a better understanding of the subject and 85% were of the opinion that the flip class approach was useful to understand the anatomical basis of neurological problems. | Strong/#615/Second year MBBS students’ views about flipped class room practice in neuroanatomy course |
| Garside, et al. (2012) | Interventional study | Simulation | 1 | Neurological emergencies, Stroke | 779 clinical staff | No comparison group | Full Text | *Journal of the Society of Simulation in Health care* | Stroke and TIA Assessment Training (STAT) uses video and audio clips from real patients in conjunction with a patient simulator to create interactive scenarios for emergency department staff. | Data from the first year of STAT showed that learner selfconfidence for stroke assessment increased significantly. The use of the simulator was highly valued. | Strong/#133/ Stroke and TIA assessment training: a new simulation-based approach to teaching acute stroke assessment. |
| Beniczky, et al. (2020) | ILAE web based learning | eLearning | 0 | Clinical Neurology, Epilepsy | N/A | No comparison group | Full Text | *Epileptic Discord* | Provides an overview on the e-learning portfolio of the ILAE, including tutored e-courses, self-paced interactive e-courses and online multimedia resources, all linked to the ILAE curriculum and learning objectives addressing specific levels of professional experience. | The ILAE offers a wide variety of e-learning courses, educational tools and resources. The continuous increase of participants and large number of students applying for these courses and the overwhelmingly positive feedback reinforce the high educational value of the ILAE e-learning programs. | Good/#3488/ e-learning comes of age: Web-based education provided by the International League Against Epilepsy. |
| Mathon, et al. (2021)   | Randomized, prospective, interventional, single-blinded study    | Art learning, drawing   | 2 | Neuroradiology   | 80 Medical students   | Standard teaching vs. Teaching through drawing  | Full Text   | *European Radiology*  | An initial evaluation was carried out to assess the students’ basic level. Three teaching and training sessions were spread over 2 months in each group. One month after the third teaching session, students were evaluated by an examiner who was blind to the student’s group. The same comprehensive evaluation grid has been used for the initial and final students’ evaluations to give an objective score out of 20 points. Students’ scores were compared between groups using the t test and effect sizes were measured using Cohen’s d.  | Students’ mean age was 21.1 years old. In total, 61.3% were female. Regarding initial evaluation, scores did not differ significantly between both groups (10.1 ± 2.0 versus 9.9 ± 1.9, p = 0.65), thus confirming the homogeneity of the students’ basic level. The scores obtained from the final evaluation were significantly higher for the “teaching through drawing” students than for the “standard teaching” students (14.7 ± 2.7 vs 13.2 ± 2.0, p = 0.009, Cohen’s d = 0.62).  | Strong/#5655/ Teaching brain imaging through a drawing method may improve learning in medical students.  |
| Donaghy, et al. (2021)   | Investigational, interventional study   | eLearning, role play   | 2 | Clinical Neurology   | 18 neurology residents   | No comparison group   | Full Text   | *MedEdPORTAL: the journal of teaching and learning resources*  | Online surveys assessed knowledge as well as confidence in the ability to recognize concerning behaviors. A practical assessment using a previously published “Stressed Resident” video was also conducted among resident cohorts.  | Of neurology residents, 18 participated in the activity, with nine in the control group and nine in the intervention group. In the postvideo survey, the residents who participated in a role-play activity outperformed a control cohort of their peers when identifying signs of burnout, mood disorders, and substance abuse portrayed in the video (84% vs. 72%; t test, p = .01). Residents indicated increased confidence in the ability to recognize symptoms of maladaptive stress as well as identify resources for themselves and peers. Participants demonstrated no difference in knowledge-based questions scores on pre- and postactivity assessments.  | Good/#5819/ An Educational Workshop to Improve Neurology Resident Understanding of Burnout, Substance Abuse, and Mood Disorders.  |
| McKendrick, et al. (2021)   | Interventional, investigational study   | Simulation   | 2 | Clinical neurology   | 40 participants, medical students   | Compared group with tracer on vs off.   | Full Text   | *Anaesthesia*  | primary outcome measures were the number of steps successfully performed and the number of errors committed during each block. Videos were scored by trained experts using validated checklists. Sequential tracker activation and deactivation was randomised equally within subjects.  | With needle activation, steps improved in 10 (25%) subjects and errors reduced in six (15%) subjects. The most important steps were: needle tip identification before injection, OR (95%CI) 2.12 (1.61–2.80; p < 0.001); and needle tip identification before advance of the needle, 1.80 (1.36–2.39; p < 0.001). The most important errors were: failure to identify the needle tip before injection, 2.40 (1.78–3.24; p < 0.001); and failure to quickly regain needle tip position when tip visibility was lost, 2.03 (1.5–2.75; p < 0.001).  | Good/#6172/ The effect of an ultrasound-activated needle tip tracker needle on the performance of sciatic nerve block on a soft embalmed Thiel cadaver.  |
| Farias Da Guarda, et al. (2021)   | Randomized, controlled, before-after study   | Simulation   | 2 | Neurological emergencies, Stroke | 17 health care professionals  | Participants compared to ENLS participants   | Full Text   | *Arquivos de Neuro-Psiquiatria*  | All participants responded pre- and post-test questionnaires evaluating their self-perception of confidence in acute stroke care, ranging from 10 to 50 points. We evaluated the variation between pre- and post-test results to assess the change on trainees’ self-perception of confidence in the management of acute stroke. M  | Forty-six (83.63%) subjects completed both questionnaires. The post-test scores were higher than those from the pretests in the stroke realistic simulation course group [pretest median (interquartile range — IQR): 41.5 (36.7–46.5) and post-test median (IQR): 47 (44.7–48); p=0.033], but not in the neurosonology [pretest median (IQR): 46 (44–47) and post-test median (IQR): 46 (44–47); p=0.739] or the ENLS [pretest median (IQR): 46.5 (39–48.2), post-test median (IQR): 47 (40.2–49); p=0.317] groups. Results were maintained after adjustment for covariates.  | Good/#5789/ Realistic simulation is associated with healthcare professionals’ increased self‑perception of confidence in providing acute stroke care: A before‑after controlled study.  |
| Van Gestel et al. (2021)  | Interventional, investigational study   | VR  | 2 | Clinical Neurology   | 16 medical students   | VR vs freehand  | Full Text   | *Neurosurgical Focus*  | The outcome was quantified by the metric accuracy of EVD placement as well as by its clinical quality.  | The mean target error was significantly impacted by either AR (p = 0.003) or training (p = 0.02) in a direct comparison with the untrained freehand performance. Both untrained (11.9 ± 4.5 mm) and trained (12.2 ± 4.7 mm) AR performances were significantly better than the untrained freehand performance (19.9 ± 4.2 mm), which improved after training (13.5 ± 4.7 mm). The quality of EVD placement as assessed by the modified Kakarla scale (mKS) was significantly impacted by AR guidance (p = 0.005) but not by training (p = 0.07). Both untrained and trained AR performances (59.4% mKS grade 1 for both) were significantly better than the untrained freehand performance (25.0% mKS grade 1). Spatial aptitude testing revealed a correlation between perceptual ability and untrained AR-guided performance (r = 0.63).  | Good/#5627/ The effect of augmented reality on the accuracy and learning curve of external ventricular drain placement.   |
| Han, et al. (2021)  | Randomized, prospective, single-blind study   | VR  | 2 | Clinical Neurology   | 98 medical students   | Standard patient vs standard patient +VRNET  | Full Text   | *BMC Medical Education*  | 1) A standardized patient(SP) group that received the clinical performance examination utilizing standard patients complaining of dizziness was provided neurological findings using conventional method such as verbal description, photographs, and video clips; 2) A SP with VRNET group that was provided the neurological findings using the newly developed tool.   | There were no statistical differences in VRNET’s realness and student satisfaction between the SP and SP with VRNET groups. However, a statistically significant difference was found in the Neurologic Physical Exam (NPE) score (p = 0.043); the SP with VRNET group had higher NPE scores (3.81 ± 0.92) than the SP group (3.40 ± 1.01).  | Strong/#5992/ Virtual reality-based neurological examination teaching tool(VRNET) versus standardized patient in teaching neurological examinations for the medical students: a randomized, single-blind study.  |
| **Ceri,et al. (2021)**  | **Randomized, Investigational, interventional study**  | **3-D Modeling**  | **1** | **Neuroanatomy**  | **120 2**nd year medical students   | **3 groups: 3-D model group vs anatomy models group vs anatomy atlas**  | **Full Text**  | ***Meandros Medical and Dental Journal***  | **They were asked to fill out a questionnaire containing their opinions about the anatomy lesson. Then, the students were randomly divided into three groups according to their learning methods.**  | **Among the participants, 75.9% stated that working on the model was sufficient and 36.7% mostly used the printed human anatomy atlas when studying for practical lesson. While the success rates of different modules were similar in the practice groups, in the same module, the success of the 3D Human Anatomy Application group was higher than that of other practice groups** | **Good/#5717/ Effect of non-cadaveric methods on the anatomy education of medical students.**  |
| Javaid, et al. (2021)   | Interventional, investigational study   | eLearning   | 1 | Neuroanatomy   | N/A  | N/A  | Full Text   | *Med Sci Educ*  | research shows promise to help break the perceived nexus between neuroanatomy-phobia and neurophobia.  | novel, interactive neuroanatomy e-learning resource rooted in the instructional design principles outlined by the eNEUROANAT-CF will improve users 'learning and understanding of neuroanatomy  | Good/#6000/ eNEUROANAT-CF: a Conceptual Instructional Design Framework for Neuroanatomy e-Learning Tools.   |
| Anbu, et al. (2021)   | Randomized, cross-sectional study   | Flipped classroom   | 1 | Neuroanatomy   | 281 2nd year medical students   | traditional lecture (control), flipped text resource, or flipped video resource  | Full Text   | *Advances in Experimental Medicine and Biology*  | Objective outcomes measured were: Knowledge gain and retention via multiple-choice questionnaires and formative exams Student perceptions and engagement using questionnaires and 2 focus groups  | All groups demonstrated significant knowledge gain post-teaching (p < 0.0001). However, regardless of engagement with pre-teaching material, no significant difference was found in knowledge gain or retention between the groups. Students engaged 21.1% more with the text rather than video resource (p = 0.0019), but spent equal time using both (p = 0.0948). All resources and teaching approaches were perceived 'very useful' with no significant differences found between groups. A qualitative approach utilising thematic analysis of focus groups identified 4 themes, including 'Attitudes towards flipped classroom', which revealed mixed reviews and perceptions from participants.  | Strong/#5821/ Evaluating the Efficacy and Optimisation of the Peer-Led Flipped Model Using TEL Resources Within Neuroanatomy  |
| Mikhaeil, et al. (2021)   | Cohort, investigational study   | Simulation   | 1 | Neurological emergencies   | 21 PGY-4 Neurology residents   | No comparison group   | Full Text   | *Journal of graduate medical education*  | Simulation-based assessment scores were compared to experience (number of SE cases each resident reported identifying and managing during residency), self-confidence in identifying and managing these cases, and their end of residency Milestones assigned by a CCC based on end-of-rotation evaluations.  | Sixteen of 21 (76%) eligible residents participated in the study. Average SE checklist score was 15.6 of 26 checklist items correct (60%, SD 12.2%). There were no significant correlations between resident checklist performance and experience or self-confidence. The average participant’s level of Milestone for epilepsy and management/treatment was high at 4.3 of 5 (SD 0.4) and 4.4 of 5 (SD 0.4), respectively. There were no significant associations between checklist skills performance and level of Milestone assigned.  | Good/#5725/ Simulation-Based Assessments and Graduating Neurology Residents' Milestones: Status Epilepticus Milestones.  |
| Fujita, et al. (2020)   | Interventional study   | Simulation   | 1 | Neurological emergencies, Stroke | Medical students   | No comparison group   | Full Text   | *Asian Journal of Neurosurgery*  | conducted the group work with the facilitators pretending to be patients, i.e., without medical training manikins.  | When the facilitators acted as patients, the students gained a more realistic and expressive perception of neurological symptoms. As a result, they expressed a high level of satisfaction with the course in the questionnaire sent immediately afterwards, regardless of their profession or prior experience.  | Good/#6088/ The Wakayama-Immediate Stroke Life Support Course: Achieving Successful Training on the Stroke Emergency System without using Mechanical Medical Training Simulators.  |
| Morris, et al. (2021)   | Interventional, investigative study   | Simulation   | 1 | Neurological emergencies   | 64 neurology residents, fellows, attending physicians   | No comparison group   | Full Text   | *Neurocritical Care*  | used a modified Delphi method to develop simulations for assessment in neurocritical care. We constructed checklists of action items and communication skills, merging ENLS checklists with relevant clinical guidelines. We also utilized global rating scales, rated one (novice) through fve (expert) for each case  | Ten evaluative simulation cases were developed. To date, 64 participants have taken part in 274 evaluative simulation scenarios. The participants were very satisfied with the cases (Likert scale 1–7, not at all satisfied—very satisfied, median 7, interquartile range (IQR) 7–7), found them to be very realistic (Likert scale 1–7, not at all realistic—very realistic, median 6, IQR 6–7), and appropriately difficult (Likert scale 1–7, much too easy—much too difficult, median 4, IQR 4–5). Interrater reliability was acceptable for both checklist action items (kappa=0.64) and global rating scales (Pearson correlation r=.70).  | Good/#5777/ Development of Neurological Emergency Simulations for Assessment: Content Evidence and Response Process.  |
| Clifton, et al. (2021)  | Feasibility, descriptive study   | 3-D modeling   | 0 | Neuroanatomy   | N/A  | N/A  | Full Text   | *Clinical Anatomy*  | The models  | The canal diameter changes on the flexible 3D-printed model accurately  | Good/#5771/ Investigation of a three-dimensional printed dynamic cervical spine model for anatomy and physiology education.  |
| Gordon, et al. (2016) | Interventional, comparative study | eLearning, video learning | 3 | Clinical Neurology | Nursing home staff and a hospital-based team of geriatrician, geropsychiatric, and neurologist | Control facilities vs. Intervention facilities | Full Text | *Journal of American Medical Directors Association* | The primary outcome variables were percentage of residents receiving antipsychotic medications and the percentage of residents who were physically restrained. Secondary outcomes included 9 other quality of care metrics from MDS 3.0. | Residents in ECHO-AGE facilities were 75% less likely to be physically restrained compared with residents in control facilities over the 18-month intervention period (OR = 0.25, P = .05). Residents in ECHO-AGE facilities were 17% less likely to be prescribed antipsychotic medication compared with residents in control facilities (OR = 0.83, P = .07) | Good/#1411/ Impact of a Videoconference Educational Intervention on Physical Restraint and Antipsychotic Use in Nursing Homes: Results From the ECHO-AGE Pilot Study |
| Dwortezky , et al. (2015) | Interventional, mixed-methods design | Simulation | 3 | Clinical Neurology, EMU | 9 neurology residents | No comparison group | Full Text | *Epilepsy and Behavior* | All nineteen incoming first-year neurology residents and 2 nurses completed a questionnaire assessing baseline knowledge and attitudes regarding seizure management prior to and following a team training program employing simulation and post scenario debriefing. We calculated the interobserver reliability of the checklist for consistency among the raters. We attempted to ascertain whether the training led to improvement in performance in the actual EMU by comparing 10 videos of resident–nurse team responses to seizures 4–8 months into the academic year preceding the curricular training to 10 that included those who received the training within 4–8 months of the captured video | Knowledge in seizure management was significantly improved following the program, but confidence in seizure management was not. Interrater agreement was moderate to high for consistency of raters for the majority of individual checklist items. We were unable to demonstrate that the training led to sustainable improvement in performance in the actual EMU by the method we used. | Good/#954/ Interprofessional simulation to improve safety in the epilepsy monitoring unit. |
| Goodarzi, et al. (2017) | Interventional study | 3-D modeling, elearning | 2 | Neuroanatomy | 249 medical students | 2-D group vs 3-D group | Full Text | *World Neurosurgery* | Participants viewed the video in either 2D or 3D format and then completed a written test of skull base neuroanatomy. Pretest and post-test performances were analyzed with independent Student’s t-tests and analysis of covariance. | Our study was completed by 249 subjects. At baseline, the 2D (n = 124, F = 97) and 3D groups (n = 125, F = 96) were similar, although the 3D group was older by 1.7 years (P = 0.0355) and the curricula of participating classes differed (P < 0.0001). Average scores for the 3D group were higher for both pretest (2D, M = 19.9%, standard deviation [SD] = 12.5% vs. 3D, M = 23.9%, SD = 14.9%, P = 0.0234) and post-test performances (2D, M = 68.5%, SD = 18.6% vs. 3D, M = 77.3%, SD = 18.8%, P = 0.003), but the magnitude of improvement across groups did not reach statistical significance (2D, M = 48.7%, SD = 21.3%, vs. 3D, M = 53.5%, SD = 22.7%, P = 0.0855). | Good/#1086/ Effect of Stereoscopic Anaglyphic 3-Dimensional Video Didactics on Learning Neuroanatomy |
| Weinstock, et al. (2015) | Interventional study | 3-D modeling/printing | 2 | Neuroradiology | N/A | No comparison group | Full Text | *Journal of Neurosurgery* | Multiple models for each patient were then printed on a 3D printer, with each construct designed to illustrate different aspects of the specific lesion. Intraoperative validation of model fidelity was performed using perioperative imaging, surgical filming, and post hoc analysis of models with intraoperative photography. | In the AVM cases, intraprocedural imaging and photography were performed and verified millimeter-level fidelity of the models (n = 5, 98% concordance, range 94%–100% with average of < 2 mm variation in the largest AVM [6-cm diameter]). The use of 3D models was associated with a 30-minute reduction in operative time (12%) in 2 cases when they were compared with matched controls as a feasibility study. | Good/#574/ Optimizing cerebrovascular surgical and endovascular procedures in children via personalized 3D printing |
| Esevez, et al. (2010) | Interventional, comparative study | 3-D modeling/printing | 2 | Neuroanatomy | 101 1st year medical students | 3D model group vs control group | Full Text | *Anatomical Sciences Education* | Quiz, participant survey | The overall quiz scores for the experimental group were significantly higher than the control group (t(85) = 2.02, P < 0.05). However, when the questions were divided into those requiring either 2-D or 3-D visualization, only the scores for the 3-D questions were significantly higher in the experimental group (F1,85 = 5.48, P = 0.02). When surveyed, 84% of students recommended repeating the 3-D activity for future laboratories | Strong/#527/ A novel three-dimensional tool for teaching human neuroanatomy. |
| Li, et al. (2016) | Intervention study | Active learning | 2 | Clinical Neurology, Localization/Visual field deficits | 13 1st year medical students | No comparison group | Full Text | *Advances in Physiology Education* | 6 question pretest/posttest, level of confidence | The percentage of correct answers was 49 23% (means SD) before the activity, and 95 8% after the activity. From a scale of 1 to 5, the average confidence level was 2.6 1.1 before the activity and 3.6 1.0 after the activity. | Good/#2367/ Active Learning in Neuroscience: A Manipulative to Simulate Visual Field Defects |
| Shah, et al. (2020) | Interventional study | Active learning, ultrasound | 2 | Neuroanatomy | 22 1st year medical student | No comparison group. | Full Text | *Brain Circ* | Pre–post workshop survey to identify opinions and perceptions about ultrasound and a pre–post workshop test to assess knowledge about neuroanatomy, neurophysiology, and related ultrasound topics. | Showed a statistically significant difference in pre‑ and posttest scores, suggesting that participants demonstrated higher levels of medical knowledge related to neurological physiology, anatomy, and ultrasound after participating in the workshop. The analysis of the pre–post survey showed participants attributed greater value to ultrasound as a useful tool for their future medical practice after participation in the event (Z = −2.45, P = 0.014). | Good/#2970/ Teaching neurological disorders with ultrasound: A novel workshop for medical students. |
| Roze, et al. (2018) | Interventional study | Art education | 2 | Clinical Neurology | Medical students | No comparison group | Full Text | *Journal of Neurological Sciences* | Students were evaluated with an assessment thirty months after their neurological rotation, including 15 questions to evaluate long-term retention of neurological semiology, and 10 to test background knowledge in general semiology | The semiology test was performed by 366/377 students from the 2013 class (standard education group) and by 272/391 students from the 2015 class, among which 186 participated in The Move (The Move group) and 86 did not (standard education group). The mean neurological semiology score was higher in the 2015 class compared to the 2013 class (p = 0.007) and remained so after adjustment for the general semiology performance (p = 0.003). The adjusted mean neurological semiology score was 1.21/15 points higher [95% CI 0.66, 1.75] in The Move group compared to the standard education group, corresponding to a 14% better ranking. | Good/#1991/ Miming neurological syndromes improves medical student's long-term retention and delayed recall of neurology. |
| Kooloos, et al. (2014) | Interventional, comparative study | Art-based curriculum, clay modeling | 2 | Neuroanatomy | 430 medical students | Experiment I: Clay Modeling Versus Live Observations, Experiment II: Clay Modeling Versus Video Observations | Full Text | *Anat Sci Educ* | The effects of learning were measured with multiple choice questions, extended matching questions, and recognition of structures on illustrations of cross-sections. Analysis of covariance with pretest scores as the covariate was used to elaborate the results. | Experiment I showed a significantly higher post-test score for the observers, whereas Experiment II showed a significantly higher post-test score for the clay modelers. This study shows that (1) students who perform clay-modeling exercises show less gain in anatomical knowledge than students who attentively observe the same exercise being carried out and (2) performing a clay-modeling exercise is better in anatomical knowledge gain compared to the study of a video of the recorded exercise. | Strong/#3792/ Anatomical knowledge gain through a clay-modeling exercise compared to live and video observations. |
| Weber, et al. (2016) | Interventional study | eLearning | 2 | Clinical Neurology, EEG | 20 Neurology residents, 12 PGY3, 8 PGY4 | No comparison group | Full Text | *Seizure* | Learning was assessed based on performance on matched pre- and post-tests covering common EEG findings including artifacts, normal variants, and abnormalities. | All residents showed improvement, from a mean score of 42.7% (95% CI 36.9– 48.5%) on the pre-test to 75.4% (95% CI 70.7–80.2%) on the post-test (p < 0.001). No significant difference was noted between the classes. Residents reported taking 1630 h to complete this teaching module spread over a 3-week rotation. | Good/#644/ An effective automated method for teaching EEG interpretation to neurology residents |
| Svirko, et al. (2017) | Investigational, interventional study | eLearning | 2 | Neuroanatomy | 869 medical students | No comparison group | Full Text | *Anatomy Science Education* | The students' scores on CAL-course-based neuroanatomy assessment and later university examinations were obtained. | Although the students reported less use of the deep approach for the neuroanatomy CAL course than for the rest of their neuroanatomy course (mean = 24.99 vs. 31.49, P < 0.001), deep approach for CAL was positively correlated with neuroanatomy assessment performance (r = 0.12, P < 0.001). Time spent on the CAL course, enjoyment of it, the amount of CAL videos watched and quizzes completed were each significantly positively related to deep approach. The relationship between deep approach and enjoyment was particularly notable (25.5% shared variance). | Good/#3592/ Teaching neuroanatomy using computer-aided learning: What makes for successful outcomes? |
| Schmidt-Kastner (2015) | Investigational, interventional, prospective study | eLearning | 2 | Clinical Neurology | 869 medical students | No comparison group | Full Text | *Neurology* | Seven cohorts of medical students (N = 869) filled in approach to learning scale and a questionnaire investigating their engagement with the CAL course. The students' scores on CAL-course-based neuroanatomy assessment and later university examinations were obtained. | Although the students reported less use of the deep approach for the neuroanatomy CAL course than for the rest of their neuroanatomy course (mean = 24.99 vs. 31.49, P < 0.001), deep approach for CAL was positively correlated with neuroanatomy assessment performance (r = 0.12, P < 0.001). Time spent on the CAL course, enjoyment of it, the amount of CAL videos watched and quizzes completed were each significantly positively related to deep approach. | Good/#309/ Effective learning resources for a neuroscience and behavior course for first year medical students-get neurology out of the textboxes. |
| Morris, et al. (2016) | Interventional study | eLearning, smart phone app  | 2 | Neuroanatomy | Medical students (n = 177 year 1; n = 167 year 2; n = 175 year 3) | Pre intro of tablet devices vs post | Full Text | *J. Comput. Assisted Learn.* | aim of this three-year study was to gather rigorous evidence about students’ use of apps on a preconfigured tablet device in a neuroanatomy practical class, their perceptions of this and the impact of the intervention on learning outcomes, using data collected from three cohorts of students between 2011 and 2013. | Results showed that students made extensive use of resources provided, considered the devices to be beneficial for learning, and found them to be easy to use with minimal support and training. Students’ ownership of touch screen devices increased significantly during the trial period as did their use of devices for academic study. Analysis of examination scores showed a statistically significant increase in performance for neuroanatomy-related questions after the introduction of tablet devices. | Good/#5306/ Mobile technology: students perceived benefits of apps for learning neuroanatomy. |
| Lewis, et al. (2011) | Randomized, interventional study | eLearning/Web based software | 2 | Clinical Neurology, Localization | 39 medical students | Intervention vs control | Full Text | *Canadian Journal of Neurological Sciences* | Satisfaction questionnaire, case based test over CNVII | There was a mean test score difference of 1.3 (CI.95 = 0.2, 2.3) that was significantly higher in the intervention group when compared to the control group. Questionnaire results were similar for both groups. | Strong/#19/ Web-based software to assist in the localization of neuroanatomical lesions |
| Roth, et al. (2020) | Randomized, comparative study | Podcast Learning | 2 | Clinical Neurology, Obstetrical neurology, Stroke | 60 residents/fellows (17 neurology) | Podcast intervention vs written curriculum | Full Text | *Journal of Graduate Medical Education* | Pre and posttests, acceptability with questionnaire | an increase in immediate posttest scores compared with pretest scores (46 of 60, 77% +/- 17% pretest versus 56 of 60, 93% +/- 10% posttest, P < .05) | Good/#1854/ Why Not a Podcast? Assessing Narrative Audio and Written Curricula in Obstetrical Neurology |
| Ng, et al. (2011) | Interventional study | Simulation | 2 | Clinical Neurology, Neuroradiology | 10 residents (neurosurgery, neuroradiology trainees) | No comparison group | Full Text | *Interventional Neuroradiology* | Technique was scored on multiple criteria by the faculty, and total time and fluoroscopy time were recorded on both attempts. | 10 residents, overall procedure time significantly decreased from 51 to 42 min (p=0.01), and total fluoro time significantly decreased from 12 to 9 min (p=0.002) between the first attempt and the second attempt. Technical skill increased significantly in navigation, vessel selection, projection setup, and road map usage. | Strong/#92/ Neuroangiography simulation using silicone models improves trainee skills |
| MacDougall, et al. (2016) | Interventional study | Simulation | 2 | Clinical neurology, brain death testing | 107 physicians (multiple specialties) | Scores compared between specialties | Full Text | *The Sciences and Engineering* | Facilitators evaluated performance with a 26-point checklist based on the most recent AAN guidel ines.  | Pre-test scores were poor (41.4%), with attendings scoring higher than residents (46.6% vs. 40.4%, p=0.07), and neurologists and neurosurgeons significantly outperforming other specialists (53.9% vs. 38.9%, p=0.003). Post-test scores (73.3%) were notably higher than pre-test scores (45.4%). Participant feedback has been uniformly positive. | Good/2651/ Simulation-based training in brain death determination |
| Gupta, et al. (2017) | Prospective, single-blinded, interventional study | Simulation | 2 | Clinical Neurology, fundoscopy | 48 neurology residents | Control vs intervention group (simulation) | Full Text | *JAMA Neurology* | The primary outcome measures were the postintervention changes in fundoscopy knowledge, skills, and total scores. The intervention group additionally received simulation-based training, which consisted of an instructor-led, hands-on workshop that covered practical skills of performing fundoscopic examination and identifying neurologically relevant findings on another fundoscopy simulator. | The intervention group had significantly higher mean (SD) increases in skills (2.5 [2.3] vs 0.8 [1.8], P = .01) and total (9.3 [4.3] vs 5.3 [5.8], P = .02) scores compared with the control group. Knowledge scores (6.8 [3.3] vs 4.5 [4.9], P = .11) increased nonsignificant in both groups. | Good/#1068/ Utility of combining a simulation-based method with a lecture-based method for fundoscopy training in neurology residency. |
| Sutter, et al. (2018) | Prospective, single-blinded, interventional study | Simulation | 2 | Neurological emergencies, status epilepticus | 58 physicians | No comparison group | Full Text | *Neurology* | Primary outcomes were time to (1) airway protection, (2) supplementary oxygen, and (3) administration of antiseizure drugs (ASDs). | All physicians recognized ongoing seizures. Airways were checked by 54% and protected by 16% within a median of 3.9 minutes. Supplementary oxygen was administered by 76% with a median of 2.8 minutes. First-line ASDs were administered by 98% (benzodiazepines 97% within a median of 2.9 minutes), and second-line ASDs by 57% within 8.1 minutes. Regarding secondary outcomes, the median time to monitor blood pressure and heart rate was 1.8 (interquartile range [IQR] 1.3–2.6) and 2.0 (IQR 1.4–2.7) minutes, respectively. Neurologic affiliation of physicians was associated with inadequate assessments of vital signs (odds ratio [OR] = 0.2; 95% CI 0.04–0.93) and most frequent administration of second-line ASDs (OR = 5.0; 95% CI 1.01–25.3). Knowing treatment guidelines and subjective certainty regarding SE diagnosis were associated with frequent administration of second-line ASDs (OR = 10.4; 95% CI 1.2–88.1). | Strong/#5122/ Emergency management of status epilepticus in a high-fidelity simulation: A prospective study. |
| Kelly, et al. (2013) | Randomized control trial | Simulation | 2 | Neuroanatomy, clinical neurology - ophthalmology | 138 1st year medical students | Intervention group vs control | Full Text | *Neurology* | Students’ preferences for each of the three methods (direct ophthalmoscopy on simulators or human volunteers, or use of fundus photographs) and recognition of normal and abnormal fundus features were assessed. | 119 (86%) completed all required elements. For learning ophthalmoscopy, 85 (71%) preferred humans to simulators. For learning relevant features of the ocular fundus, 92 (77%) preferred photographs to ophthalmoscopy on simulators or humans. Accuracy of answers was better when interpreting fundus photographs than when performing ophthalmoscopy on simulators (p<0.001). Performance improved after specific teaching about assessing fundus photographs before testing (p=0.02). Examination of the ocular fundus was found easier and less frustrating when using photographs than when using ophthalmoscopy on simulators or humans. Eighty-four students (70%) said they would prefer to have fundus photographs instead of using the ophthalmoscope during upcoming clinical rotations. | Strong/#1253/ Teaching ophthalmoscopy to medical students (totems). |
| Johnson, et al. (2019) | Randomized, prospective, interventional study | Simulation | 2 | Neurological emergencies, Stroke | 51 medical students | No comparison group | Full Text | *Journal of Interprofessional Educational Practice* | Using a quantitative descriptive one group pretest/posttest design, stroke care, TeamSTEPPS® knowledge and attitudes toward IPE were assessed. After an initial survey, students were given online modules on stroke care and TeamSTEPPS®. | Improvement was seen in knowledge assessment, cumulative psychomotor scores, and each affective item (p < 0.001) after SBME. These results demonstrate simulation-based IPE to be an effective vehicle to deliver TeamSTEPPS® principles and enhance stroke education at all levels of training. | Good/#5125/ Interprofessional Simulation to Deliver Stroke Management and TeamSTEPPS® Content. |
| Dlugaiczyk, et al. (2018) | RCT, prospective | Smart phone, App | 2 | Clinical Neurology | Medical students | 67 students control group, 46 used aVOR app | Full text | *Otol. Neurotol.* | Students were asked to arrange the steps of the canalith repositioning procedure in the correct order in a written test. Student satisfaction assessed. | Significantly more students of the aVOR group than the control group arranged the steps of the canalith repositioning procedure correctly in the final exam (56.3% versus 25.9%, Fisher’s exact test: P ¼ 0.00 | Strong/4729/ The aVOR app increases medical students' competence in treating Benign Paroxysmal Positional Vertigo (BPPV) |
| Johnson, et al. (2013) | Randomized, comparative study | TBL, VR (virtual reality) | 2 | Clinical Neurology, Cranial nerve palsies, localization | 57 2nd yearmedical students | Individual vs team member | Full text | *Medical Teacher* | Pre and posttests, student perspectives | An aptitude-treatment interaction (ATI) effect was detected; at pre-test scores 50%, students in teams scored higher (83%) at post-test than did students as individuals (62%, p ¼ 0.02). Post-simulation, students in teams reported greater confidence in their ability to diagnose CN abnormalities than did students as individuals (p ¼ 0.02; mean rating ¼ 4.0/5.0 and 3.4/5.0, respectively). | Strong/#1297/ Optimal learning in a virtual patient simulation of cranial nerve palsies: the interaction between social learning context and student aptitude. |
| Henssen, et al. (2020) | Interventional, comparison study | VR | 2 | Neuroanatomy | 31 medical and biomedical students | Augmented reality vs. Cross section learning | Full Text | *Anatomical sciences education* | Pretest (extended matching questions, double-choice questions and a test on cross-sectional anatomy) and a mental rotation test (MRT) were completed, as well as posttest. | Students who worked with cross-sections (n = 16) showed significantly more improvement on test scores than students who worked with GreyMapp-AR (P = 0.035) (n = 15). Further analysis showed that this difference was primarily caused by significant improvement on the cross-sectional questions. Students in the cross-section group, moreover, experienced a significantly higher germane (P = 0.009) and extraneous cognitive load (P = 0.016) than students in the GreyMapp-AR group. No significant differences were found in motivational scores. | Good/#1911/ Neuroanatomy Learning: Augmented Reality vs. Cross-Sections |
| Akle, et al. (2018) | Interventional study | 3-D modeling, Art learning | 1 | Neuroanatomy | 2nd, 4th semester medical students | Group who built clay model vs. Did not | Full Text | *Anatomical Sciences Education* | Students were provided with an instructional video before building the models of the structures, and thereafter took a computer-based quiz. They then brought their clay models to class where they answered questions about the structures via interactive response cards. Their knowledge of periventricular structures was assessed with a paper-based quiz. | Quiz scores of students that constructed the models were significantly higher than those taught the material in a more traditional manner (P < 0.05). Moreover, the modeling activity reduced time spent studying the topic and increased understanding of spatial relationships between structures in the brain. The results demonstrated a significant difference between genders in their self-perception of their ability to contemplate and rotate structures mentally (P < 0.05). | Good/#1171/ Validation of clay modeling as a learning tool for the periventricular structures of the human brain |
| Nowinski, et al. (2015) | Pilot, feasibility study | 3-D modeling/printing | 1 | Neuroanatomy | N/A | No comparison group | Full Text | *Neuroradiology Journal* | The atlas has been constructed from multiple 3T and 7T magnetic resonance angiogram (MRA) brain scans, and 3T phase contrast and inflow MRA neck scans of the same specimen in the following steps: vessel extraction from the scans, building 3D tubular models of the vessels, spatial registration of the extra- and intracranial vessels, vessel editing, vessel naming and color-coding, vessel simplification, and atlas validation. | The atlas is valuable for medical students and residents to easily get familiarized with the extracranial vasculature with a few clicks; is useful for educators to prepare teaching materials; and potentially can serve as a reference in the diagnosis of vascular disease and treatment, including craniomaxillofacial surgeries and radiologic interventions of the face and neck. | Good/#3373/ Three-dimensional stereotactic atlas of the extracranial vasculature correlated with the intracranial vasculature, cranial nerves, skull and muscles. |
| Tai, et al. (2015) | Feasibility study | 3-D printing, Simulation | 1 | Neuroanatomy | N/A | No comparison group | Full Text | *Journal of Neurosurgery* | In this study, the authors used the advantages of 3D printing to directly build the model geometry from stealth head CT scans and build a phantom brain mold based on 3D scans of a plastinated human brain. | The resultant simulator provides realistic haptic feedback during a procedure, with visualization of catheter trajectory and fluid drainage. A multiinstitutional survey was also used to prove content validity of the simulator. | Good/#566/ Development of a 3D-printed external ventricular drain placement simulator: Technical note. |
| Stevens, et al. (2016) | Interventional study | Peer/Team based learning | 1 | Clinical Neurology | 20 neurology residents | No comparision group | Full Text | *Neurology* | Pre and post-pod surverys, (1) satisfaction with resident didactics and (2) perceived impact of teaching on resident fund of knowledge. | There was in increase in resident satisfaction with the educational component of their program and perceived medical knowledge after participating in the pod system, with 5 of the 6 questions showing a significant increase in positive responses (p , 0.05) compared to the pre-pod survey | Good/#625/ Education Research: The pod system: An innovative strategy to reform residency teaching sessions in neurology |
| Keller, et al. (2019) | Interventional Study | Simulation | 1 | Neurological emergencies | Fellows | No comparison group | Full Text | *The Journal of Teaching and Learning Resources* | The checklist and debriefing material facilitated delivery of formative feedback to learners. We distributed anonymous surveys at the end of the sessions to evaluate participants’ subjective experiences. | Following curriculum implementation, there was an improvement in self-perceived confidence of fellows in neurologic emergency management skills | Good/#1580/ ICU Emergencies Simulation Curriculum for Critical Care Fellows: Neurologic Emergencies. |
| Rostanski, et al. (2018) | Interventional study | Simulation | 1 | Neurological emergencies, Stroke/tpa administration | 47 PGY2 Neurology Residents | No comparison group | Full Text | *Neurology* | Pre assessment on how participants learned to perform IV-tpa consent, post simulation survey on how prepared they felt for the IV-tPA consent case, how useful it was, and how they would rate their performance on a Likert scale from 1 to 5 (worst to best). | Participants stated they felt only somewhat prepared for the OSCE (mean Likert score = 3.4/5) and believed they performed fairly well (mean Likert score = 3.5/5), but they found the IVtPA case to be very helpful (mean Likert score = 4.8/5). | Strong/#1107/ Education research: Simulation training for neurology residents on acquiring tPA consent: An educational initiative. |
| Khan, et al. (2018) | Interventional Study | Simulation | 1 | Neurological emergencies, Stroke | Advanced practice providers, neurology residents | No comparison group | Full Text | *Stroke* | APPs and residents completed a survey before and after the simulation. | On a 5-point Likert scale (1 = strongly disagree and 5 = strongly agree), confidence in leading a stroke code increased from 2.4 to 4.2 (p < 0.05) among APPs. APPs reported improved comfort level in rapidly assessing a stroke patient for thrombolytics (3.1–4.2; p < 0.05), making the decision to give thrombolytics (2.8 vs 4.2; p < 0.05), and assessing a patient for embolectomy (2.4–4.0; p < 0.05). There was no difference in the improvement observed in all the survey questions as compared to neurology residents. | Good/#1140/ Stroke code simulation training benefits advanced practice providers similar to neurology residents. |
| Anderson, et al. (2018) | Interventional Study | Simulation | 1 | Clinical Neurology, EEG | Pediatric neurology residents | No comparison group | Full Text | *The Journal of Teaching and Learning Resources* | The goals of this simulation are for residents to treat a seizing infant in an emergency department setting, identify status epilepticus, develop a differential diagnosis that includes vitamin B6 deficiency, and correctly administer pyridoxine. | Feedback evaluations for the case showed that it improved resident education and clinical skills.  | Good/#2004/High-Fidelity Simulation Scenario: Pyridoxine-Dependent Epilepsy and Treatment. |
| Morris, et al. (2020) | Interventional Study | Simulation | 1 | Clinical Neurology, Brain Death | PGY-2,3 neurology residents | No comparison group | Full Text | *The Journal of Teaching and Learning Resources* | The residents worked with an interdisciplinary team and responded to the family’s emotions, used active listening skills, and supported the family through next steps. | Twelve residents completed the simulations. Prior to the simulation, three (25%) residents felt comfortable discussing a brain death diagnosis; following the simulation, eight (67%) residents felt comfortable/very comfortable discussing brain death. Prior to the simulation, eight (67%) residents stated they knew prerequisites for performing a brain death examination and seven (58%) agreed they knew indications for ancillary testing; these numbers increased to 100% following the simulation. The number of residents who felt comfortable performing the brain death exam increased from five (42%) to 10 (83%). | Good/#2145/ Brain Death Determination: An Interprofessional Simulation to Determine Brain Death and Communicate with Families Focused on Neurology Residents. |
| Hocker, et al. (2015) | Interventional study | Simulation | 1 | Clinical Neurology, Brain death | 41 critical care and neurology trainees | No comparison group | Full Text | *Neurocritical care* | evaluated using a 24-point checklist based on the AAN guidelines. Trainees rated their confidence (5 point scale with 1 = novice, 3 = competent, and 5 = fully confident) in the evaluation of brain death and apnea testing before and after completing the scenario. | Trainees successfully completed 352/492 (71.5 %) tasks pertaining to the evaluation of prerequisites and 262/369 (71.0 %) tasks pertaining to the clinical examination. Trainee confidence in the evaluation of brain death (2.12 ± 0.74 vs 3.29 ± 0.62, p = 0.0001) and apnea testing (2.10 ± 0.74 vs 3.59 ± 0.77, p = 0.001) significantly improved. | Strong/#584/ Testing Confounders in Brain Death Determination: A New Simulation Model |
| Sun, et al. (2018) | Interventional study, comparison study  | Simulation | 1 | Clinical Neurology – Lumbar puncture | 60 neurology 1st year residents | Traditional teaching vs. Problem and simulator based eLearning | Full Text | *World Neurosurgery* | After training, we assessed the extent that the residents were ready to perform LP and tracked successful LPs performed by the residents. We then asked residents to complete questionnaires about the training models. Performance scores and the results of questionnaires were compared between the 2 groups. | Students and faculty concluded that PSBL provided a more effective learning experience than the traditional teaching model. Although no statistical difference was found in the pretest, posttest, and improvement rate scores between the 2 groups, based on questionnaire scores and number of successful LPs after training, the PSBL group showed a statistically significant improvement compared with the traditional group. | Strong/#1149 Evaluation of Problem- and Simulator-Based Learning in Lumbar Puncture in Adult Neurology Residency Training |
| Holling, et al. (2015) | Interventional, comparison study | Simulation | 1 | Clinical Neurology – Brain death | 120 4th year medical students | Intervention group (simulation) vs control | Full text | *Journal of Surgical Education* | One group attended an additional practical course on the evaluation of brain death and received training using a new high-fidelity simulation device. The other group did not participate in any additional training session. All students completed a questionnaire before the lecture and a second questionnaire at the conclusion of the study. For the group undergoing the additional training, the second questionnaire was completed after the additional training session. | The additional practical training session significantly improved the students’ performance in assessing brain death and promoted the self-assessment and motivation of the medical students | Strong/#337/ Teaching the concept of brain death in undergraduate medical education. |
| Larsen, et al. (2010) | Interventional, pilot study | Simulation | 1 | Clinical Neurology – ophthalmoscopy | Medical Students | No comparison group | Full Text | *Medical Education* | Students were observed and instructed on the correct use of the ophthalmoscope. Both normal and pathological retinas were used. The students matched what they observed with printed photographs to verify what they had actually seen.A pre- and post-session questionnaire, with comments, was completed. | A total of 64 percent of the students elected to participate when a faculty member was present to instruct them, whereas only 12 per cent of the class elected for the experience without instruction. The self rating results from the pre versus post-session questionnaire showed statistically significant improvement for all items. Student comments reflected that they felt strongly that the experience was valuable to them. | Good/#497/ Ophthalmoscopy using an eye simulator model. |
| Hennessey, et al. (2016) | Interventional study | Social Media, Twitter | 1 | Neuroanatomy | 197 2nd year medical students | No comparison group | Full Text | *Anatomical Sciences Education* | Student usage was tracked to measure levels of engagement throughout the course and frequency of hashtag use was compared to examination results. Student opinions on the use of Twitter were obtained during a focus group with eleven students and from qualitative questionnaires | The hashtag was used by 91% of the student cohort and, within this, more students chose to simply view the hashtag rather than make contributions. The completed questionnaire responses (n = 150) as well as focus group outcomes revealed the value of using Twitter. A negligible correlation was found between student examination scores and their viewing frequency of the hashtag however, no correlation was found between examination scores and contribution frequency. Despite this, Twitter facilitated communication, relieved anxieties and raised morale, which was valued highly by students and aided engagement with neuroanatomy. | Good/#683/ Social media and anatomy education: Using twitter to enhance the student learning experience in anatomy. |
| Smeby, et al. (2020) | Cross over, comparative study | Team based learning (TBL) | 1 | Neuroradiology | 105 3rd year medical students | 2x2 cross over – Group 1 (CT-didactic learning, MRI - TBL | FULL TEXT | *Acad Radiol* | Assessed by results on a neuroradiology section of the end of-year written examination | There were no statistically significant differences in student scores on the examination. Students reported high levels of engagement, and reported being more satisfied overall with the TBL sessions than traditional lectures. | Good/#3614/ Express Team-Based Learning (eTBL): A Time-Efficient TBL Approach in Neuroradiology. |
| Stepan, et al. (2017) | Randomized, controlled, Interventional study  | VR  | 1 | Neuroanatomy | 66 medical students | 33 experimental group vs 33 control group | Full Text | *International Forum of Allergy and Rhinology* | evaluated the students’ anatomy knowledge, educational experience, and motivation (using the Instructional Materials Motivation Survey [IMMS], a previously validated assessment). | There was no significant difference in anatomy knowledge between the 2 groups on preintervention, postintervention, or retention quizzes. The VR group found the learning experience to be significantly more engaging, enjoyable, and useful (all p < 0.01) and scored significantly higher on the motivation assessment (p < 0.01). | Strong/#1073/ Immersive virtual reality as a teaching tool for neuroanatomy. |
| Kucuk, et al. (2016) | Interventional study, experimental | VR/AR (augmented reality) | 1 | Neuroanatomy | 70 2nd year medical students | 34 experimental group, 36 control group | Full Text | *Anatomical Sciences Education* | Determine the effects of learning anatomy via mAR on medical students’ academic achievement and cognitive load. | The experimental group, which used mAR applications, reported higher achievement and lower cognitive load. The use of mAR applications in anatomy education contributed to the formation of an effective and productive learning environment. | Good/#2362/ Learning Anatomy via Mobile Augmented Reality: Effects on Achievement and Cognitive Load |
| Nowinski, et al. (2013) | Feasibility study | 3-D modeling/printing | 0 | Neuroanatomy | N/A | No comparison group | Full Text | *Journal of Neurosciences Methods* | A scalable user interface was designed with 12 modules including central nervous system (cerebrum, cerebellum, brainstem, spinal cord), cranial nerves, muscles, glands, arterial system, venous system, tracts, deep gray nuclei, ventricles, white matter, visual system, head. | Anatomy exploration operations include compositing/decompositing, individual/group selection, 3D view-index mapping, 3D labeling, highlighting, distance measuring, 3D brain cutting, and axial/coronal/sagittal triplanar display | Good/#1275/ Three-dimensional interactive and stereotactic atlas of head muscles and glands correlated with cranial nerves and surface and sectional neuroanatomy. |
| Javan, et al. (2017) | Feasibility study | 3-D modeling/printing | 0 | Neuroanatomy | N/A | No comparison group | Full Text | *Journal of Digital Imaging* | Feasibility of successful design and production of 3D printed model | successful design and production of 3D printed model | Good/#1058/ Nerves of Steel: a Low-Cost Method for 3D Printing the Cranial Nerves |
| Douglas, et al. (2021)   | Investigational, interventional study   | eLearning   | 2 | Clinical Neurology   | 158 medical students   | No comparison group   | Abstract   | *Neurology*  | Questions about the cases followed a Likert scale format (0–4) and were added to the routine student course survey administered by the Office of Evaluation and Assessment  | Mean scores were higher for cases that included videos in all four categories queried and statistically significant in three: effectiveness for learning (3.03 vs. 2.78, p=0.003), understanding pertinent exam findings (3.13 vs. 2.98, p=0.06), memorability (3.13 vs. 2.63, p=5×10^9), prompting collaborative discussion (3.14 vs. 2.97, p=0.01). 13/36 facilitators responded to the feedback survey. 12/13 thought videos were easy to use, 9/13 agreed videos stimulated discussion, and 8/13 felt all small group cases would benefit from the addition of video.  | Good/#5697/ A Video is Worth a Thousand Words: Perceived Learning Value in Video versus Text-Based Cases.  |
| Frey, et al. (2021)   | Investigational study   | Flipped classroom   | 2 | Clinical Neurology   | 1st year medical students   | No comparison group   | Abstract   | *Neurology*  | The first part consisted of a flipped classroom to teach the standard neurologic examination. The second part involved patient encounters modeled off of the traditional patient rounds. Students rotated from room to room, listening to patients’ experiences with different neurologic diseases and eliciting pathologic neurologic examinations. Students were surveyed before and after Neuro Day.  | The result of the binomial test indicated that the proportion of medical students interested in neurology significantly increased from 78% to 85% (95% confidence interval [CI] 0.79–0.92; p = 0.034) after participating in Neuro Day. The proportion of students’ knowledge of clinical neurology increased from 45% to 63.1% (95% CI 0.54–0.72; p < 0.0001), comfort with performing a neurologic examination increased from 30% to 78.4% (95% CI 0.70–0.86; p < 0.0001), and fear of studying neurology decreased from 46% to 26% (95% CI 0.17–0.34; p < 0.0001) following Neuro Day. One hundred percent of students indicated that they would recommend Neuro Day to their peers.  | Good/#5730/ Training in Neurology: Neuro Day: An Innovative Curriculum Connecting Medical Students With Patients.  |
| Il'yazova, et al. (2021)  | Investigational, interventional study   | Gamification   | 2 | Clinical Neurology, Movement disorders   | 28 medical students   | No comparison group   | Abstract   | *European Journal of Neurology*  | Each participant filled pre- and post course screening of the knowledge on movement disorders.  | 28 students participated in the experimental course - 37% men, 63% women, average of 23 years old. 78% of participants competed in the game. 30% of game participants were attendees of each universities' neurology club. 71% of students completed a course of neuroanatomy, syndromology in neurology, 29% fully completed clinical course of neurology. According to results, the average improvement was 19,2%. The highest increase (68.8%) of correct answers was in Q3, while the number of correct answers dropped in only Q2 (12,9%). However, no participant demonstrated a 100% improvement after the session. All students demonstrated high interest and involvement.  | Good/#5668/ New methods of education in movement disorders for medical students.  |
| Mantri, et al. (2021)  | Investigational, pilot, interventional study   | Gamification   | 2 | Clinical Neurology   | 45 medical students   | Intervention group compared to 41 controls   | Abstract   | *Neurology*  | NBME examination scores from these students were tabulated and compared by Mann-Whitney test to a historical control cohort enrolled in the Neurology clerkship in the prior academic year. The historical controls participated in a conventional session that reviewed examination items without gamification. An end-of-clerkship survey collected student feedback.  | The median shelf score (interquartile range, IQR) was 79 (72–87) for the innovation group compared to 84 (78–86) for controls (p=0.31). Fourteen of 34 respondents (41.2%) to the end-of-clerkship survey rated Neuro-Jeopardy as “extremely helpful” or “moderately helpful.” Written feedback was mixed, with some students praising the game as “fun and informative” while others found it “frightening” and became “more stressed” after playing. Commercial question banks were the resource most often rated “useful” for both the NBME examination (29/37, 78.4%) and the clerkship (31/37, 83.8%).  | Good/#5700/ Neuro-Jeopardy and Neurophobia: Lessons from a Pilot Intervention.  |
| Vishnu, et al. (2019)   | Multi-center, cross-sectional study   | Smart phone app   | 2 | Clinical Neurology   | 100 neurology residents   | No comparison group   | Abstract   | *Annals of Indian Academy of Neurology*  | Primary outcome was proportion of correctly identified high likely gold standard differential diagnoses. Secondary outcomes were proportions of correctly identified first high likely, first three high likely, first five high likely and combined moderate plus high likely gold standard differentials  | Residents correctly identified the gold standard “high likely” differentials with a frequency of 13.6% as against 41.5% by the App (95% CI: 21.9-34.1). On combining “high” and “moderate likely” differentials, residents could accurately identify gold standard differentials with a frequency of 10.8% as against 37.9% by the App, (95% CI 22.6-31.9). The residents correctly identified first five high likely gold standard differentials with a frequency of 13.5% versus 23.7% by the App (95% CI 5.3-15.9). The residents correctly identified first three high likely gold standard differentials with a frequency of 13.0% versus 15.8% by the App (95% CI-1.2-7.9). Residents correctly identified the first “high likely” gold standard differential in 32.3% as against 35% by the App (95% CI:-8.4-15.6).  | Good/#5919/ Deducing differential diagnoses in movement disorders: Neurology residents versus a novel mobile medical application (neurology dx).  |
| Souza, et al. (2020)  | Between-subjects experiment, investigational study   | VR  | 2 | Neuroanatomy   | 23 medical students   | Virtual model vs physical model   | Abstract   | *IEEE*  | A between-subjects experiment was conducted with 23 students to jointly assess learning, knowledge retention, and sense of presence.  | Results shown high mean scores in the virtual condition. When comparing the knowledge test performance before and immediately after the experiment, we found significant difference only for the virtual condition. The same can be observed for retention.  | Good/#6250/ The Effect of Virtual Reality on Knowledge Transfer and Retention in Collaborative Group-Based Learning for Neuroanatomy Students.  |
| Fyllos, et al. (2021)   | Investigational, interventional study   | 3-D Modeling, Art learning   | 1 | Neuroanatomy   | 80 medical students   | No comparison group   | Abstract   | *Journal of Hand Microsurgery*  | 80 students participated as volunteers in the demonstration course. They evaluated course usefulness and their own confidence after the course  | According to the 5-point Likert scale, the participants' confidence increased in a statistically significant way ( p < 0.05). All participants (100%) stated that their skills were "significantly improved" in terms of instrument handling, anatomy studying, performing digital anesthesia, and suturing technique. Overall experience was rated as "satisfactory" or above.  | Good/#5993/ Description and Validation of an Innovative and Effective Hand-Shaped Suture-Training Model for Medical Students.  |
| **Nadcimento, et al. (2021)** | **Interventional study** | **ELearning** | **1** | **Clinical Neurology** | **76 medical students** | **No comparison group** | **Abstract** | ***Neurology***  | **Satisfaction surveys were distributed to medical students who participated in NeuroLytes in order to assess their subjective perception of these sessions as well as their overall perspective on how education was impacted by COVID-19.** | **Students identified that their learning experience after the pandemic was most affected by decreased interaction with patients (85.5%), other students (73.6%), residents (46.1%), attendings (53.9%), as well as decreased motivation to study (52.6%). Students also felt their ability to learn the neurological exam, take a history, and reason clinically would be most affected (51.5%, 69.7%, and 42.4% respectively). Satisfaction with NeuroLytes has been reported as high - 86% strongly agreed or agreed that NeuroLytes should continue. Additionally, there was a significant increase in student rating of teaching sessions prior (median of 4/5) and after (median of 4.3/5) NeuroLytes (p=0.01). Similarly, there was a significant increase in student rating of overall educational experience on the clerkship as a median of 3.5 before and 3.9 after (p=0.02).** | **Good/#5705/ Neuro Lytes as a novel, virtual,case-based didacticstargeted at medicalstudents undergoing Neurology clerkship.** |
| **Lubarsky (2020)**  | **Investigational study, interventional**  | **eLearning, movie utilization**  | **1** | **Clinical Neurology**  | **Medical students**  | **No comparison group**  | **Abstract**  | ***Medical Education***  | **In their review, students were requested to provide their thoughts on the accuracy of the protagonist's depiction of the neurological illness, on how the various characters portraying health professionals (physicians, nurses, social workers, and others) were represented, and on the reactions and responses of the family members, friends and caregivers of the character affected by neurological illness in the movie. On the last day of the course, students were invited to share and discuss the content of their written reviews with their peers (in groups of seven to eight) in tutor-facilitated online small group sessions.**  | **We found that students did a fair amount of independent reading in order to appraise the portrayals of the neurological disorders in the films. Although they were not explicitly instructed to reflect on the COVID-19 pandemic, several students drew insightful parallels between their feelings of social isolation and those expressed by the characters in the films who felt ‘trapped’ in their own bodies as a result of their neurological conditions. Although watching movies cannot reproduce the experiential learning that occurs through direct interactions with human beings affected by neurological illness, we found ‘cinemeducation’ to be a particularly useful and enjoyable method for maintaining neurological education under the extenuating circumstances of the COVID-19 pandemic.** | **Good/#6205/ Movie night! An entertaining online educational method for introducing students to common presentations in neurology.**  |
| **Kaplan, et al. (2021)** | **Interventional study** | **eLearning, virtual learning** | **1** | **Clinical Neurology** | **Medical students** | **No comparison group** | **Abstract** | ***Neurology***  | **Students were empowered to revise teaching cases to reflect a more representative and diverse patient population. 4) Appropriate assessments: Exams were open book. Analytical, multistep questions maintained a challenging and enriching educational experience.** | **Was the year’s highest student-rated course overall, even surpassing traditional in-person pre-COVID courses, and the highest rated course in specific learning environment questions including, ‘respecting diversity’ and ‘showing respectful interaction with students.’ 91.4% of students agreed that this course consistently engaged them to apply critical thinking to solve problems and 92.2% of students agreed that assessments were fair and accurate evaluations of their ability.** | **Good/#5695/ Fostering an Inclusive and Supportive Virtual Learning Environment in a Remote Preclinical Neuroscience Medical School Course.** |
| Duncan, et al. (2021)   | Interventional study   | PBL  | 1 | Clinical Neurology    | Medical students   | No comparison group   | Abstract   | *Neurology*  | Using module surveys administered by UTRGV, we will compare student perception of PBL. Perceptions will be quantified by how they rated PBL.  | Feedback from last year’s PBL session showed that 68.00% of students agree that neurology PBL was a useful way to learn about basic science and its application to patient care and clinical practice. Preliminary feedback from this year’s class indicates greater satisfaction with PBL than last year, where there was no neurologist involved, and formal feedback is in progress.  | Good/#5704/ Neurology Problem Based Learning with Limited Neurologist Resourcesis Feasible.  |
| Nobleza, et al. (2020)   | Interventional, investigational study   | Role play   | 1 | Clinical Neurology   | 12 Neurology residents   | No comparison group   | Abstract   | *Annals of Neurology*  | Outcome measures included post-session resident survey, participation and attendance during each session.  | The mean number of residents present in each activity was 10±1. The activity with the highest post-session survey response rate (50%) was critical care of stroke (first activity) for which all the residents either agreed or strongly agreed that the activity increased medical knowledge, system based knowledge and facilitated teamwork among housemates. There was attrition noted in the post-session survey response. Resident participation in all activities were high as noted by videos and pictures taken during the sessions. There were also noted additional benefits such as improved house-team-spirit, involvement and interaction among residents and attendings.  | Good/#5864/ Hogwarts house grouping for a combined wellness and assessment initiative for resident trainees in neurology (Hogwarts-Neurology).  |
| Fiedler, et al. (2021)   | Investigational study   | Simulation  | 1 | Clinical Neurology   | 12 PGY-2 Neurology Residents   | No comparison group   | Abstract   | *Neurology*  | The primary outcome was perceived efficacy of teamwork between EM and neurology residents, which was objectively obtained via a 50-point Likert scale-based survey. The secondary outcome of interest included retention of clinical knowledge after long-term post-intervention assessment, which was measured via MCQ assessment.  | Post-intervention, affective surveys showed sustained improvements in perceptions of teamwork efficacy in EM and Neurology cohorts compared to baseline. Both EM and neurology residents demonstrated quantitative post-intervention retention of acute stroke care knowledge compared to pre-intervention assessments.  | Good/#5708/ Team is Brain: An Interdisciplinary Educational Initiative to Improve Stroke Care in the Emergency Department.  |
| Nobleza, et al. (2020)   | Interventional study   | Simulation   | 1 | Neurological emergencies   | 18 PGY-2 Neurology trainees   | No comparison group   | Abstract   | *Annals of Neurology*  | The primary outcome measure was mean(SD) level of perceived preparedness (LPP) for independent call as measured by a 5-point Likertlike scale. Long-term feedback from former PGY-2 Neurology residents (2016-2018) regarding the SNES course were collected. Student t-test was utilized to compare the preSNES and post-SNES preparedness scores.  | The mean LPP was significantly higher in post-SNES for all components of each case scenario except for AIS (AP, Mx, PA and HO) and SC Mx. 100% of former PGY2NR respondents stated that the course helped prepare them for PGY-2 independent call and helped them manage emergent and acute neurologic conditions beyond PGY-2 Neurology year. Annual SNES was found to be feasible and sustainable.  | Good/#5862/ Simulation for neurologic emergencies and acute scenarios (SNES) course: A 4-year evolutionary experience of utilizing simulation for incoming PGY-2 neurology residents to prepare them for independent calls.  |
| O’Hare, et al. (2020)  | Exploratory Study   | Smart phone app   | 1 | Clinical Neurology   | Medical students   | No comparison group   | Abstract   | *Muscle and Nerve*  | The final product is a single-screen, easy-to-use iPhone app, in which users can see a simplified root/plexus/nerve diagram overlaid on a cartoon limb.  | Impact on measures of task-specific self-efficacy and knowledge base will be assessed pre and post-exposure to the resource.  | Weak/#5865/ Development of a novel educational neurolocalization tool.  |
| Nascimento, et al. (2021)   | Interventional study   | Social Media, Instagram   | 1 | Clinical Neurology   | N/A  | N/A  | Abstract   | *Neurology*  | Reach and readership engagement were measured by tracking social media account users and average engagement.  | From January 2019 to October 2020, 70 posts were delivered across three social media platforms: 54 were Teaching (Video) NeuroImages, 6 Pearls and Oy-sters, 7 e-Pearls, 2 Mystery Cases, and 1 Child Neurology post. Over this time, social media followers increased on all platforms: 312.5% on Instagram, 12.9% on Twitter, 10% on Facebook. On Twitter, there was an increase in impressions (74.5%), engagements (121%), and post link clicks (38.7%). On Facebook, there was a 34.6% increase in total engagements. Overall, teaching Video NeuroImages produced the highest level of engagement. Posts with polls and/or quizzes were well received by audience on all platforms and also received high levels of participation  | Good/#5707/ Educating trainees through social media-The Resident and Fellow Section Social Media Initiative.  |
| Thompson-Stone (2021)  | Investigational, exploratory study   | TBL  | 1 | Clinical Neurology   | 13 medical students, 10 neurology faculty   | No comparison group   | Abstract   | Neurology   | The program included the following core components: (1) large group meetings aimed at teaching professional development and medical problem-based learning, (2) mentor meetings, (3) clinical shadowing experiences, and (4) a clinical project. In addition, students benefitted from networking opportunities for summer programs, letters of recommendation, and help with medical school applications. Program evaluation data was obtained by anonymous surveys and activity tracking.  | The program recruited 13 students, 10 neurology faculty mentors, and 14 medical student junior mentors. The overall quality was rated as 4.6/5 with improvement between year 1 and year 2. The program facilitated the following estimated activities over 2 years: 55 in-person senior mentor meetings, 36 in-person junior mentor meetings, 62 shadowing experiences, and 408 email communications. Student reported strengths included ease of shadowing, usefulness of problem-based learning cases, mentor relationships, and encouragement received. Areas for improvement included desire for more meetings and shadowing, and an increased formal role for junior mentors.  | Good/#5694/ Creation of a Longitudinal, Clinical Undergraduate Pipeline Program to Engage Underrepresented Individuals in Neurology.  |
| Sargon (2019)   | Investigate, exploratory study   | 3-D modeling   | 0 | Neuroanatomy   | Medical students   | No comparison group   | Abstract   | *Surgical and Radiologic Anatomy*  | Transverse and coronal sections of brains about 5-6 mm in thickness were taken from fixed human brains. Then; the routine silicone plastination technique including dehydration, forced impregnation and hardening were applied to all of the brain sections.  | By the examination of the silicone brain section plastinates; the students have the chance of examining the real brain sections for many hours instead of the schematic drawings found in many atlases. Silicone section plastinates of brain also detailed the real anatomy seen in the few neuroanatomical models  | Good/#5929/ Better neuroanatomy education with silicone section plastinates.  |
| Maclean, et al. (2021)   | Feasibility, investigational study   | eLearning   | 0 | Neuroanatomy   | N/A  | N/A  | Abstract   | *ACSME Conf.*  | While virtual and synthetic dissection simulation tools alleviate the need for procuring and maintaining costly resources, like cadavers, these tools are costly, inaccessible to students online, and inadequate in the teaching of practical knowledge needed to solve real-life clinical problems.  | The web-based visualization repository presented is intended to provide medical students with a comprehensive, web-based visual and problem-based learning tool to assist their learning of anatomical and neurophysiological concepts as applied to various medical disorders.  | Good/#6358/ Web-based 3D visualization system for anatomy online instruction.  |
| Mallampali, et al. (2021)   | Investigational study   | eLearning, forum   | 0 | Clinical Neurology   | Trainees, students, providers   | No comparision group | Abstract   | *Neurology*  | site includes forums to discuss specific topics, a resource library, event notices, grant and other funding opportunities and job offerings. MSC also provides commentary on newly published manuscripts, webinars and educational videos and features a mentor program to connect emerging researchers with established researchers.  | Since the official launch of MSC, we have had 140 unique logins. We have established nine different discussion forums with 41 discussion threads so far with several members joining more than one community. User activity on MSC is measured as engagement points and the top three factors earning the most points so far are page views, in-network messaging and discussion group subscriptions. Demographic breakdown of current members: 36 researchers (PhDs and clinical), 46 practicing clinicians, 23 trainees (post-doctoral fellows, residents, clinical fellows and graduate students) and 17 international members  | Good/#5691/ Migraine science collaborative: A novel innovative web-based networking and communication platform to enhance and advance migraine research.  |
| Chow, et al. (2021)   | Interventional study  | eLearning   | 2 | Clinical Neurology   | Neurology residents   | No comparison  group   | Abstract  | *Neurology*  | Participants were asked to complete a short, multiple-choice pretest based on pertinent content from the guideline. The same questions were asked at the end of the presentation. Responses were pooled to evaluate variation and overall understanding of the topic.  | To date, four sessions have been completed. A total of 27 individuals have completed the pretest and 24 completed the post-test. The difference was attributed to dropout during the presentation. Responses to 13 questions were recorded and analyzed. Overall, participants’ average score increased from 42% (SD = 15%) to 93% (SD = 12%), t(24)= −8.60, p < .001.  | Good/#5703/ Improving Trainee and Practicing Providers Education and Understanding of AAN Clinical Practice Guidelines through Interactive Video Conferences.  |
| Liang, et al. (2020)   | Investigational, interventional study   | eLearning   | 2 | Clinical Neurology, EMG/NCS  | 6 neurology residents   | No comparison group   | Abstract  | *Muscle and Nerve*  | Anonymous pre- and post-test surveys were administered to evaluate resident perception of the curriculum's value, preferred learning styles, and self-reported confidence with the Accreditation Council for Graduate Medical Education (ACGME) milestones in NCSs/needle EMG and neuromuscular disorders.   | Six PGY-3 neurology residents completed the pre-test survey and 4 completed the post-test survey. Comparison of the pre-/post-test survey results revealed greater confidence in achievement of ACGME milestones at the end of the rotation. The most commonly reported barrier to learning needle EMG/NCSs was lack of time due to other responsibilities. Residents found hands-on experience in the EMG laboratory and neuromuscular clinic to be very beneficial but rated a variety of different learning approaches highly.  | Good/#5866/ Results of a novel digital curriculum in EMG/NCS for neurology residents.  |
| Richardson, et al. (2017) | Interventional study | Simulation | 4 | Neurological emergencies, Stroke | Neurology residents | Post simulation times compared to pre simulation DTN times | Abstract | *Stroke* | Scenarios were developed in collaboration with a Vascular attending and fellow. Emergency department nurses, EMS, chaplains, and pharmacist all participated in the scenario to make it as realistic as possible. A mannequin was utilized and controlled by simulation lab personnel while participants were videotaped as they performed the scenario. Incorporated into the debriefing of the scenario was education of door to needle goals, stroke alert process, and a discussion of role expectations. | After providing simulation education to residents, the door to needle (DTN) average decreased to 39.8 minutes with a p-value of 0.0794. Before the education we met the goal of administering Alteplase in less than 60 minutes, 80% of the time. Following the education we met the goal 89% of the time | Good/#745/ Multidisciplinary simulation of stroke alerts in resident education leads to a 20% decrease in door to needle times. |
| Kelly, et al. (2014) | Interventional Study | Simulation | 4 | Neurological emergencies, Stroke | 17 neurology residents | No comparison group | Abstract | *Neurology* | Residents’ self-perceived ability to effectively counsel patients and families before and after the exercise were compared. Temporal trends in the hospital’s time to initiate intravenous thrombolysis for stroke were investigated, incorporating the months before and after simulation exercises | 17 adult neurology residents underwent simulation exercises, including an immediate debriefing with the simulated patient and a more lengthy self-assessment following review of a video recording of the simulation. Residents’ self-perceived preparedness to perform relevant counseling regarding acute stroke was improved post-simulation, though this did not reach statistical significance (p>0.05). Mean door-to-thrombolytic treatment time for acute stroke was significantly improved in the 6 months following institution of simulation exercises compared to the previous 18 months (54 minutes vs. 69 minutes, p=0.01). | Good/#904/ Development of a simulated patient exercise to improve acute stroke care by neurology residents. |
| Zaika, et al. (2018) | Interventional study | Simulation | 3 | Neuroradiology | Medical students | No comparison group | Abstract | *FASEB Journal* | Over the span of 6 sessions, participants were assessed on their procedural pace, coiling quantity and quality, and perforation rates. Concurrently, their spatial ability was assessed using a mental rotations test (MRT) and used in the performance analysis. | Found that all individuals were able to perform the procedure faster after 6 sessions, reducing their average time from 42 to 24 minutes. Coil success rate improved over from 82% to 88% and coil packing rate remained consistent at 30% throughout testing. High perforation rate seen at the start of the study showed a trend of decreasing over the latter sessions, however, over half of aneurysms were still being perforated by the novice participants. No change in aneurysm coiling quality was found, with a slight decrease in number of parent artery coil protrusions. | Good/#1445/ Cerebral aneurysmal coiling in virtual reality - An overview of novice skill development. |
| Sivakumar, et al. (2013) | Interventional study | eLearning | 3 | Clinical Neurology | Neurology residents | No comparison group | Abstract | *Neurology* | Subsequent modules are unlocked upon completion of prerequisites. In addition, attainment of skill sets is tracked through self-reported case-logs, professionalism and communication skills are tracked through role-playing sessions and mentorships with faculty, and resident and faculty surveys are conducted for feedback and system change. | Three months after initiation of this novel web based method, resident attendance and participation had significantly increased. | Good/#1250/ Web based interactive learning: A novel method for achieving neurology milestones. |
| Stork, et al. (2013) | Interventional study, pilot study | Simulation | 3 | Neurological emergencies, Stroke | 23 physicians (13 Neurology, 10 Emergency medicine) | No comparison group | Abstract | *Stroke* | Entrance and exit surveys were administered to measure changes in knowledge, skills, and attitudes. The use of rtPA for AIS was tracked before and after the intervention. | 17 neurology and emergency medicine residents have completed the workshop. All trainees reported significantly increased confidence in AIS patient selection and management with rtPA, including its potential complications. Intravenous rtPA use increased by 75% in the 7 months after residents began participating in the workshop (no protocol violations). This increase has persisted at 13 months after the initial simulation. | Good/#224/ Simulation: A novel modality for improving physician knowledge and confidence with recombinant tissue-type plasminogen activator for acute ischemic stroke |
| Allen, et al. (2017) | Interventional, cross-over study | 3-D modeling, eLearning | 2 | Neuroanatomy | 144 medical students | 3-D group vs. 2-D group | Abstract | *FASEB Journal* | Participants completed a first post‐module assessment prior to switching to the other e‐learning resource. A second postmodule assessment was administered following participants' exposure to the second learning resource. Data was also collected for the time spent by participants using each learning modality. | Participants who initially accessed the 3D e‐learning resource had a significantly greater increase in score between the pretest and the first post‐module assessments than the students who initially accessed the 2D e‐learning resource. Participants who viewed the 3D e‐learning resource following access to the 2D elearning resource significantly improved their scores between the first and second post‐module assessments. Total time spent using both e‐learning resources did not significantly differ between groups. Participants who initially accessed the 3D resource spent equivalent amounts of time using each resource, whereas participants who initially accessed the 2D resource spent significantly more time using the 3D resource than the 2D resource. | Good/#969/ Impact of integrating interactive neuroanatomy elearning resources on novice student learning. |
| Novroski, et al. (2018) | Interventional Study | 3-D modeling, VR | 2 | Neuroanatomy | 13 PGY-2, PGY-4 Neurology residents | No comparison group | Abstract | *Neurology* | The RITE was administered to all residents one month after course completion over five consecutive years. Neuroanatomy percentiles scores were analyzed for each individual learner in three consecutive years. | Neuroanatomy percentile scores decreased in 85% (11/13) of residents from PGY-2 to PGY-3 year. Overall, a total of 64 percentile points in neuroanatomy were lost despite one extra year of training. Neuroanatomy percentile scores increased in 92% (12/13) of residents from PGY-3 to PGY-4 years. Interestingly, cumulative percentile points of 138 were gained in neuroanatomy, compared to only 69 cumulative percentile points overall, indicating a disproportionate improvement in neuroanatomy compared to other tested areas. | Good/#1461/ Intensive neuroanatomy boot camp curriculum demonstrates improved neurology residency in-service training examination (RITE) scores |
| Kokro, et al. (2015) | Randomized, observation, interventional study | 3-D modeling, VR | 2 | Neuroanatomy | 169 2nd year medical students | 3-D (intervention group) vs 2-D (control group) | Abstract | *Annals of Anatomy* | Students completed a 10-question multiple-choice exam based on the content learned and a subjective evaluation of the teaching method immediately after the lecture. | Students in the 2D group achieved a mean score of 5.19 (±2.12) compared to 5.45 (±2.16)in the 3D group, with the results in the 3D group statistically non-inferior to those of the 2D group (p < 0.0001). The students rated the 3D method superior to 2D teaching in four domains (spatial understanding, application in future anatomy classes, effectiveness, enjoyableness) (p < 0.01). | Good/#364/ Stereoscopic neuroanatomy lectures using a three-dimensional virtual reality environment. |
| Allen, et al. (2016) | Cross over, investigational study | 3-D modeling/printing | 2 | Neuroanatomy | 87 medical students | 3-D initial exposure group vs gross anatomy | Abstract | *FASEB Journal* | A final post-module knowledge assessment was administered following student exposure to the second learning modality.  | Students who initially accessed the 3D module scored significantly higher on the first post-module knowledge assessment than the students who initially accessed the gross anatomy laboratory. Students who accessed the 3D learning resources following gross anatomy resources, significantly improved on the final post-module knowledge assessment. A negative correlation was observed between spatial ability and change in assessment score following access to the 3D module suggesting that students with low spatial ability experienced a greater positive effect on their learning of neuroanatomy following the use of the 3D learning module than students with higher spatial ability. | Good/#1355/ Effect of spatial ability on enhancing neuroanatomy education with an interactive 3D E-learning module. |
| Allen, et al. (2018) | Interventional study, cross-over design | 3-D Modeling/printing | 2 | Neuroanatomy | 173 medical students | Intervention group vs control | Abstract | *FASEB Journal* | Each group initially completed an anatomy knowledge pretest, followed by access to either the 3D or 2D neuroanatomy e-learning resource. Participants completed both an anatomy knowledge quiz and virtual syncretion assessment prior to utilizing the second learning resource. A second anatomy knowledge 7/14/2021 Positive Impact of an Interactive 3D Neuroanatomy E‐learning Resource on Students' Spatial Neuroanatomical Knowledge - Allen - 2018 … https://faseb.onlinelibrary.wiley.com/doi/abs/10.1096/fasebj.2018.32.1\_supplement.635.23 2/3 quiz and virtual syncretion assessment were administered following participants' exposure to the second e-learning resource. | Anatomy knowledge quiz scores of participants who initially accessed the 3D learning resource increased significantly more than the students who initially accessed the 2D elearning module. Participants who initially utilized the 3D e-learning resource performed significantly better on the digital syncretion assessment than participants who initially utilized the 2D e-learning resource. Additionally, participants who accessed the 3D elearning resource subsequent to the 2D e-learning resource significantly improved their performance on the final virtual syncretion assessment. No significant improvement in performance was observed for participants who accessed the 2D e-learning resource subsequent to the 3D e-learning resource. | Good/#1441/ Positive impact of an interactive 3d neuroanatomy e-learning resource on students' spatial neuroanatomical knowledge |
| Benameur, et al. (2020) | Comparison study | 3-D modeling/printing  | 2 | Neuroanatomy | Neurology providers | No comparison group | Abstract | *Neurology* | Pre-tests represented knowledge acquired from the traditional 2D program. Post-tests represented knowledge acquired from the 3D online course. The course was evaluated by a Likert scale on; Clarity of concepts taught, quality of 3D models,convenience of the online course. | A total of 159 APPs enrolled in the course. The pre-test average score was 40%, the post-test average score was 75%. The Course was rated using the Likert scale as follows; Clarity of concepts taught 4.5/5; Quality of 3D models 5/5; Convenience of online course 5/5. | Good/#2079/3D model simulation is more effective in teaching functional neuroanatomy to apps |
| Byler, et al. (2015) | Comparision, interventional study | eLearning | 2 | Clinical Neurology, Pediatric Neurology | 8 control and 8 adult neurology residents | Control and intervention groups | Abstract | *Annals of Neurology* | Mixed methods study utilizing standardized test scores from residency in-training examinations and a Likert scale questionnaire examining attitudes and self-reported efficacy in treating children with neurologic diseases. | All participants achieved significant improvement over baseline test scores (p<.002); control subjects had variable results with no significant change. Comparison with controls was limited by baseline differences in test scores between the groups. Participants had significant improvement in self-reported efficacy over baseline in all areas (p<0.01) except headache treatment age 13-18. Residents reported satisfaction with the length, complexity and utility of the curriculum approach. | Good/#561/ Utility and effectiveness of a self-directed interactive learning tool for adult neurology residents learning pediatric neurology |
| Bhatti, et al. (2018) | Interventional study | eLearning | 2 | Clinical Neurology, Movement disorders | 16 neurology residents | No comparison group | Abstract | *Neurology* | Coursework included weekly modules with required and optional reading material, task assignments (such as mind map, memory matrix), formative quizzes, discussion forums, twitter feeds and podcast. Course performance was evaluated with blinded pre-test and post-test questionnaire. | Of 16 residents 15 completed pre-test and 11 completed post-test for evaluation. There were 5777 online page views over 5 weeks (mean 385/resident, range 32–1319). Residents made 167 submissions with timely submission rate of 55% (CI 37–73, range 0–100%), completed 5 weekly quizzes with average score of 65.9% overall as a group (range 58.9–71.3%). There were 86 responses posted within 12 discussion topics. Eleven residents completed post-test with 100% showing an improvement on the score (average 23.8% CI 20.4–27.2, range 10–46%). Pre-test score average was 41% (n=15, range 2–72%) and post-test score average was 72.7% (n=11, range 48–86%). Combined Score for all assessments (total 410) for all 15 residents was 35.8% on average (mean 147, CI 113–180, range 1.2–80.8%) showing large spread of results due to variable participation. | Good/#1470/ Effectiveness of blended learning for resident education in neurology: Experience from movement disorder course. |
| Marsicano, et al. (2011) | Randomized, Interventional, comparative study. | eLearning | 2 | Clinical Neurology | 30 residents/house staff | Web based learning group vs (control) paper article group | Abstract | *Gastroenterology* | Both control and study groups completed a pre-test prior to randomization and a post-test following review of provided materials. The tests consisted of eight multiple-choice. | Twenty eight of 30 completed all components of the study including both pre and post-tests. No difference in mean score was observed between control and intervention subjects on the pre-test (control=4.92 questions answered correctly, intervention=5.08; p=0.920). The pre-test mean score for the intervention group was 5.08, and the post-test mean for this group was 7.08 (p<0.001). In the control group, no difference between pre- and post-test score was noted (pre-test mean=4.92, post-test mean=5.50; p = 0.267). | Good/#37/ Using a web-based module to educate internal medicine, neurology house staff and medical students regarding the appropriate use of stress ulcer prophylaxis: A randomized controlled trial. |
| Cubo, et al. (2017) | Interventional study | eLearning, tele-education | 2 | Clinical Neurology, movement disorders | 125 medical students | No comparison group. | Abstract | *Movement disorders* | Six videoconferences covering hyperkinetic and hypokinetic movement disorders were included. Pre and post knowledge and satisfaction questionnaires were collected. | Both groups reported being moderately to highly satisfied with the program. Attendance ranged from 75.6% (Argentina) to 54% (Cameroon). Compared to baseline, the mean number of correct answers in the post-knowledge test improved 22% among the Argentinian students and 15% among the Cameroon students | Good/#1021/ Movement Disorders tele-education program for undergraduate medical students in low-middle, high income countries |
| Asukile, et al. (2019) | Interventional Study | eLearning, video based learning | 2 | Clinical Neurology, EEG | 161 participants (neurologists, residents, technologists, and 12 other doctors) | No comparison group | Abstract | *Journal of Neurological Sciences* | Pre- and Post-course multiple-choice question (MCQ) test results and EEGonline user logs were analysed. Differences in pre- and post-test performance were correlated with quantified exposure to various EEGonline learning modalities. Participants’ impressions of EEGonline efficacy and usefulness were assessed through Pre- and Post-course perception surveys. | Ninety-one participants attempted both pre- and post-course tests. Mean scores were 46.7% before the course and 64.1% after the course (pb0.0001). Initial analysis revealed that post-course test performance was better in participants accessing interactive EEG-activities versus didactic lecture-notes. | Good/#1829/ Online EEG teaching – Identifying the most effective and preferred learning methods on a web-based EEG training course |
| Strowd, et al. (2015) | Interventional study | eLearning, video based learning | 2 | Clinical Neurology | 38 medical students | No comparison group | Abstract | *Neurology* | Course impact was assessed by (1) a 5-question single-best answer multiple choice knowledge examination at orientation and exit, (2) four end-of-clerkship survey questions assessing satisfaction and application of knowledge using a 5-point Likert scale and compared to prior rotations, and (3) Neurology NBME Shelf Exam scores. | This novel curriculum was piloted in 38 students; 21 male (55[percnt]); 21[percnt] in their second and 79[percnt] their third year. Mean clinical reasoning knowledge score improved from 41+19[percnt] at baseline to 70+23[percnt] at clerkship exit (mean difference 28[percnt], 95[percnt]CI 23-34[percnt], p<0.001). Students were satisfied with the clerkship with a median rating of 4 (range 1-5) on overall educational value, 5 (3-5) for obtaining a history and physical, 4.5 (2-5) for developing a differential diagnosis, and 4 (3-5) for discriminating when to consult neurology. Mean NBME scores (75.4+8.6) did not suffer and were similar to prior scores in the same academic year (78.1+7.3, p=0.09) and in the year prior (77.7+7.4, p=0.23). CONCLUSIONS: A video-based curriculum on clinical reasoning was well received by neurology clerkship students, facilitated self-directed content review, and provided opportunity for a “flip classroom” case-based review. Student performance was not negatively impacted and improved on a clinical reasoning content exam. | Good/#311/ Impact of a novel video-based curriculum for teaching clinical reasoning in neurology. |
| Anbu, et al. (2020) | Interventional study | Flipped classroom | 2 | Neuroanatomy | 215 2nd year medical students | Flipped classroom vs. Traditional didactic lecture | Abstract | *Journal of Anatomy* | The students were blinded and completed a pre-teaching test, post-teaching test and perception survey (response rate = 75.3%) | showed a significant increase of 0.81 marks in mean post-teaching scores (p=0.03) when comparing flipped to didactic teaching. However, of the Flipped group, only 38.2% engaged with the pre-reading material. Perception survey analysisrevealed that students taught via the Flipped approach ranked.their knowledge as significantly higher both before and after teaching (p<0.001) | Good/#1882/ Flipping the Classroom: Exploring the effects of a flipped approach on knowledge gain and student perceptions within a neuroanatomy near-peer teaching program. |
| Strowd, et al. (2016) | Interventional, comparison study, prospective block-randomized study | Flipped classroom | 2 | Clinical Neurology | 104 medical students | Flipped classroom vs online instruction | Abstract | *Neurology* | Baseline and end-of-course knowledge was assessed by peer-reviewed multiple choice exams and NBME shelf examination; faculty/resident clinical evaluations; non-compulsory assignment completion was used to track SDL; and satisfaction by end-of-clerkship survey. | 104 students (49 flipped, 55 online) were enrolled. While age, gender, and training level did not differ by group (all p>0.43), baseline knowledge was higher in the live group (mean score 27.6±11 vs 21.5±10, p=0.003). Faculty/residents rated clinical skills were higher in the live group (4.2±0.5 vs 3.9±0.7, p=0.03) including higher rating of future housestaff potential (4.8±0.3 vs 4.5±0.6, p=0.03). Students in the online group were more likely to display SDL (42 vs 12[percnt], p=0.001) and reported more hours devoted to studying (6.1 vs 3.8 hrs, p=0.03). While exam performance did not differ by group, NBME scores tended to be higher after adjusting for differences in baseline knowledge (2.3, 95[percnt] CI -0.4-4.8, p=0.07). Satisfaction was not different by group (p=0.51) | Strong/#1385/ Flipped versus online-only instruction in the neurology clerkship: A comparative effectiveness study of best-practices in medical education. |
| Novroski, et al. (2018) | Interventional, Randomized, cross over study | Flipped Classroom | 2 | Clinical Neurology, EEG | Neurology residents | Pre-reading material vs none group  | Abstract | *Neurology* | A clinical neurophysiology trained instructor was present for questions, feedback, and interactive instruction. A 30 question EEG test was used to compare scores before and after the reading and classroom work as well as to compare those given reading material prior to or after classroom activities. | Preliminary data after two classroom sessions shows a significant improvement in test scores (0.28+/−0.16 vs. 0.43+/−0.12; P = 0.02). There was no significant difference in post-testing based on whether instructional reading material was provided prior to (0.42+/− 0.1) or after (0.43+/−0.17) classroom activities. | Good/#1459/ Flipped classroom: Applications in teaching EEG. |
| Vishnu, et al. (2019) | Multi-center, cross sectional, observational study | Smart phone app, AI | 2 | Clinical Neurology | 100 neurology residents | No comparison group | Abstract | *Journal of the Neurological Sciences* | Participating residents were asked to deduce relevant differential diagnoses to a set comprising of 15 Movement Disorder vignettes. Differential diagnosis of Neurology residents and the app were compared against the gold standard differentials derived by experts. | Residents correctly identified the gold standard “high likely” answers with a frequency of 13.64% as against 41.5% by the App (95% CI: 21.90–34.07, P b .0001). On combining “high” and “moderate likely” answers, residents could accurately identify gold standard differentials with a frequency of 10.78% as against 37.92% by the App, (95% CI 22.56– 31.94, P b .0001). | Good/#1830/ Neurology residents versus a mobile medical application in deducing differential diagnoses in movement disorders: A multi-center, cross-sectional, observational study |
| Depika, et al. (2020) | Interventional, comparative study | Near peer teaching | 2 | Neuroanatomy | 16 3rd year medical students | Traditional lecture style vs. Problem based learning in Near peer teaching program | Abstract | *Journal of Anatomy* | Pre/posttest, perception survey | While students demonstrated significant knowledge gain with both approaches (p<0.0001), analysis showed no significant difference in mean normalised knowledge gain. | Good/#1889 Exploring whether traditional lecture or problem based learning approaches improve knowledge gain and student perceptions within neuroanatomy near-peer teaching / |
| Fahy, et al. (2015) | Pilot, interventional study | Podcast | 2 | Clinical Neurology, EEG | 14 medical students, 10 1st year residents | Compared 14 medical students to 10 residents | Abstract | *Medical Science Education* | Evaluation tools were unique for each assessment time period, comprising 25 questions designed for curriculum evaluation. Scores represent the correct number of questions. | The mean scores with standard deviations were 8.43 ± 2.38 at baseline, 13.64 ± 2.71 after the podcast (p ≤ 0.0001), and 14.86 ± 2.63 (p ≤ 0.0001) after interpreting 10 EEGs. Statistical analysis revealed evaluation scores for the podcast group increased between baseline and after 10 EEG interpretations comparable to controls that received the traditional lecture-based EEG curriculum (p = 0.003) (control group: baseline = 9.70 ± 1.49, after 10 EEGs = 13.44 ± 2.30). Video podcasting in this pilot study as measured by the evaluation tools was more effective for increasing EEG knowledge than traditional lecture-based didactics.  | Good/#4484/ Podcast Model for Medical Student Electroencephalogram Instruction. |
| Vakani, et al. (2014) | Interventional study, comparison study | PBL | 2 | Clinical Neurology | 30 participants | Problem based vs lecture based learning groups | Abstract | *Journal of the College of Physicians and Surgeons* | Both groups were given a pre and a post-test. Pre/post assessment was done using one-best MCQs. | Cronbach's alpha was 0.672 for the lecture group and 0.881 for TBL group. Item analysis for difficulty (p) and discriminatory indexes (d) was obtained for both groups. The results for the lecture group showed pre-test (p) = 42% vs. post-test (p) = 43%; pre- test (d) = 0.60 vs. post-test (d) = 0.40. The TBL group showed pre -test (p) = 48% vs. post-test (p) = 70%; pre-test (d) = 0.69 vs. post-test (d) = 0.73. Lecture group pre-/post-test mean scores were (8.52 ± 2.95 vs. 12.41 ± 2.65; p < 0.001), where TBL group showed (9.70 ± 3.65 vs. 14 ± 3.99; p < 0.001). Independent t-test exhibited an insignificant difference at baseline (lecture 8.52 ± 2.95 vs. TBL 9.70 ± 3.65; p = 0.177). The post-scores were not statistically different lecture 12.41 ± 2.65 vs. TBL 14 ± 3.99; p = 0.07). | Good/#869/ Task-based learning versus problem-oriented lecture in neurology continuing medical education. |
| Agarwal, et al. (2014) | Feasibility/interventional, randomized study | Simulation | 2 | Neurological emergencies | 10 PGY-2 neurology residents | Simulation group vs traditional didactic | Abstract | *Neurocritical Care* | identification of key actions, Ottawa CRM checklist, and knowledge based pre- and post-intervention tests | Acute stroke case: mean key action scores (maximum score 28) were 17.8±1.5 & 16.4±2.9, difference in scores were 0.32±0.3 & 0.2±0.3 after simulation and didactics interventions respectively. ICP crisis case: mean key action scores (maximum score 24) were 16.4±4.6 & 17.3±0.6, difference in scores were 0.14±0.19 & 0.13±0.11, for simulation and didactics groups respectively. Status epilepticus case: mean key action scores (maximum score 38) were 31.8±3.4 & 28±3.9, difference in gain on post-test scores were 0.2±0.24 & 0.28±0.4 after simulation and didactics interventions respectively. There were no statistically significant differences found between groups for either of the pre-specified outcomes. | Strong/#935/ High-fidelity simulation versus traditional didactic techniques for teaching neurological emergencies to neurology residents: A feasibility study |
| Donaghy, et al. (2019) | Intervention study | Simulation | 2 | Clinical Neurology, Brain death | 9 Residents/18 Attendings (preexposure), 3 residents/9 attendings (post exposure) | No comparison groups | Abstract | *Neurocrit Care* | Knowledge base, comfort levels performing brain death examination | Knowledge significantly improved from pre- to post-exposure (59% correct, range 18-91% improved to 76% correct, range 64-91%; p=0.0002). Comfort levels in performing the brain death examination pre-exposure also increased from pre- to postexposure (pre: “Very Comfortable-30%”,“Somewhat Comfortable-37%”,”Neutral-7%”,”Somewhat or Very Uncomfortable-26%” to post: “Very Comfortable-50%”, “Somewhat Comfortable-33%”,”Very Uncomfortable-17%” [p=0.005]). |  Good/#2046/ Improving knowledge and comfort in clinical brain death testing in neurology residents and attendings utilizing both didactic and simulation exercises: A quality improvement study |
| Albin, et al. (2019) | Interventional and comparative study | Simulation | 2 | Neurological emergencies | 20 neurology residents | Standardized patient vs manakin group | Abstract | *Neurocritical care* | Before and after the course, residents completed a 40-question multiple-choice test on management of neurologic emergencies and a survey about their confidence in managing 15 neurologic emergencies. A detailed task checklist was used to assess decision making during the simulations. | Both resident groups had statistically significant higher knowledge and confidence scores after their training sessions (Knowledge: pre: 49% vs post: 72%, p<0.001; Confidence: average pre: 0.98 to post: 2.01, p<0.001). However, there was no statistically significant difference between the two groups in either knowledge or confidence. | Good/#1517/ Effectiveness of standardized patient versus manikin in simulation-based education of neurocritical care concepts: A pilot study |
| Pressman, et al. (2012) | Interventional study | Simulation | 2 | Clinical Neurology – Lumbar puncture | 12 neurology residents | Compared prior training results to current intervention | Abstract | *Neurology* | Residents were reassessed with a 22-point checklist while performing an LP on a simulator. The overall assessment score, number of needle passes, and nine key safety components were measured. | Compared to original pre-test scores, the assessment scores remained significantly higher (P=0.004), and the number of needle passes remained significantly lower (P=0.010) than prior to the original intervention one year earlier. Safety standards remained significantly improved (P=0.009). These scores did not vary significantly based on number of LPs performed over the past year, or by the year of residency. While the overall safety standards improved, the number of residents obtaining mastery standards did not change significantly (P=0.131). | Good/#142/ Retention of lumbar puncture skills gained by a mastery learning approach using simulation technology and deliberate practice. |
| Tariq, et al. (2012) | Interventional study | Simulation | 2 | Neuroradiology | Neuroradiology fellows | No comparison group | Abstract | *Neurology* | Participants performed simulated procedures to investigate construct validity and instructional effectiveness., The performances of the operators before and after training on the device were categorized by using three objective outcome measures (fluoroscopy time, aneurysm coil mass compaction, and rate of technical errors). | Two of the three objective outcome measures (fluoroscopy time and rate of technical errors) showed a statistically significant improvement (p<0.05). After the three cases, the ESN fellows' performance was able to approach the faculty's performance in regards to fluoroscopy time, aneurysm coil compaction and rate of technical errors. | Good/#149/ Endovascular surgical neuroradiology simulator is of benefit in the acquisition of basic and intermediate skills by novice fellows. |
| Loomis, et al. (2016) | Interventional study | Simulation | 2 | Neurological emergencies | 8 neurology residents | No comparison group | Abstract | *Neurology* | Residents completed pre- and post-simulation surveys including questions about level of comfort managing neurological emergencies, based on a 5-point Likert scale. Neurology faculty members assessed resident performance using milestones based assessment tools | Eight residents participated. Residents reported statistically significant increased comfort levels following the simulation with obtaining a history (AIS mean pre 3.31, mean post 4.38, p=0.017; SE mean pre 2.5, mean post 3.5, p= 0.051), ordering IV TPA (AIS mean pre: 2.25, mean post 3.25, p=0.043), examination skills (SE mean pre 2.5, mean post 3.5, p= 0.051) and choosing anti-epileptic drugs (SE mean pre 1.88, mean post 3.38 p=0.008). The mean subcompetency scores ranged from 1.9 to 2.2 for AIS, and 1.6 to 2.1 for SE. Mean inter-rater differences in assessment of sub-competencies ranged from 0.14 to 0.94 points on the 5-point Milestones scale, and 94[percnt] of all ratings differed by one point or less between observers. | Good/#1380/ Simulation of neurological emergencies for milestones-based learning and assessment. |
| Kornspun, et al. (2019) | Interventional study | Simulation | 2 | Neurological emergencies, Stroke | 104 3rd year medical students | No comparison group | Abstract | *Stroke* | All participants completed pre- and post-simulation tests targeting clinical knowledge of EMAS (score range 0-7). Additionally, 45 students completed an anonymous post-simulation survey on subjective feelings of confidence managing acute stroke and seizure (Likert scale of 1-5). | Mean EMAS test score improved from 4.85 (SEM 0.089) pre-simulation to 5.25 (SEM 0.101) post-simulation (p<0.01). Students demonstrated significant improvement on questions assessing the role of supplemental oxygen in EMAS (p<0.01) and lacunar stroke syndromes (p<0.05). Subjectively, 77.8% of participants reported that simulation was the best form of acute stroke instruction they received, and 73.4% agreed or strongly agreed that the simulation improved their level of comfort with EMAS. | Good/#1552/ Using simulation to improve medical student knowledge and comfort in early management of acute stroke |
| Legault, et al. (2018) | Interventional study | Simulation | 2 | Neurological emergencies, Stroke | 22 neurology, pediatric neurology residents | No comparison group | Abstract | *Neurology* | Immediate effect of simulation was measured with a pre- and post- multiple-choice quiz and thematic coding of openended resident written feedback. Long-term impact of simulation was surveyed with a 5-point Likert scale at 1 year and free text comment box. | Quiz grades improved from 67.5% to 78.3% after simulation. Common feedback themes reference comfort with code logistics, imaging order entry, team member roles, benefit of realistic scenarios, and desire for more scenarios. The residents perceived simulation would relieve the stress of stroke call. At 1 year, all residents continued to feel comfortable with codes including tPA criteria and orders and NIHSS exam. 100% agreed simulation had sufficiently prepared them for stroke call. 83% agreed scenarios reflected their real-life experience. | Good/#1458/ Stroke code simulation has sustained benefit on neurology resident education and preparedness for stroke call |
| Lukovits, et al. (2012) | Interventional Study | Simulation | 2 | Neurological emergencies, Stroke | Neurology Residents | No comparison group | Abstract | *Neurology* | For each scenario, a checklist based on these goals was used to calculate the percentage of items done satisfactorily ("score"). A survey for residents to critique the exercises was used in debriefing sessions. | The median, average, range and standard deviation for the scores on scenario 1 (ischemic stroke/thrombolysis were: 64%, 62%, 32-77%, and 12.5. The median, average, range and standard deviation for the scores on scenario 2 (cerebellar hemorrhage) were: 85%, 86%, 80-100%, and 6.7. Residents' evaluation of the exercise was consistently very positive. | Good/#138/ Novel simulation lab exercises for training neurology residents how to manage acute stroke |
| Mutch, et al. (2016) | Interventional study | Simulation | 2 | Neurological emergencies, Stroke | Neurology trainees | No comparison group | Abstract | *Stroke* | Neurology and neuroradiology faculty debriefed participants following simulations. Questions on stroke care (derived from the 2013 AHA/ASA guideline and 2015 update) were sent to likely participants before and after the simulation; those who completed pre/post quizzes and the simulation were included in analysis. | Survey response rate was 86%. All participants had improved scores on the post-simulation quiz, scoring an average of 19% higher, 95% CI [8%, 29%]. For example, correct responses that IV tPA is not contraindicated prior to endovascular therapy improved from 64 to 100% after the simulation; responses correctly identifying the appearance of ischemic penumbra on CT perfusion imaging increased from 27 to 73%. Nearly all (92%) respondents would recommend the simulation to their peers. | Good/#632/ Multidisciplinary stroke simulation: Novel team based approach to decrease door-to-needle times. |
| Pirmohamed, et al. (2016) | Interventional study | Simulation | 2 | Clinical Neurology, peripheral nerve block | Neurology residents | No comparison group | Abstract | *Headache* | Appropriate indications for the use of the procedure and current accepted techniques were included in the initial didactics. Learners then participated in a simulation based curriculum. Participant’s medical knowledge was assessed via written test before and after completing the curriculum. | Medical knowledge was assessed via written test before and after completing the curriculum and showed a 57% increase in competency. Post curriculum evaluations revealed that 95% of participants found the exercise to be useful and 97% thought this would be useful in their future neurological practice. | Good/#1402/ An interactive simulation based curriculum for the use of peripheral nerve blocks in headache management |
| Ciccotto, et al. (2012) | Interventional study | Simulation | 2 | Clinical Neurology, Lumbar puncture | 42 4th year medical students, 31 3rd year medical students | No comparison group | Abstract | *Neurology* | Students completed a questionnaire at start assessing their comfort level and procedure knowledge. They were then presented our SIMC Teaching Module, which consists of LP procedure slide presentation followed by practical experience on LP mannequins. Post module assessment included practical checklist and a second questionnaire assessing effect on comfort level, knowledge, and technical skill. | Pre and post-module comparisons include increases in knowledge of: LP indications, side effects and complications, proper manometer use, needle position, and stylette use (among others). Finally comfort level, as previously presented, increased from 51.0% answering “not at all comfortable” to only 4.0% at post-module. Overall student comfort level increased from 2.2 to 3.6, an increase of 61% (p<0.01). | Good/#145/ Lumbar puncture teaching module standardization. Ensuring patient safety through proper training. |
| Dworetzky, et al. (2012) | Interventional study | Simulation | 2 | Clinical Neurology, Epilepsy | Neurology residents, nurses | No comparison group | Abstract | *Neurology* | Knowledge and attitudes regarding seizure management before and immediately after a simulated team training curriculum were assessed during resident orientation. Resident-nurse teams were videotaped in two scenarios based on actual EMU sentinel events. Three trained and blinded clinical experts scored videotaped performances using a previously validated checklist. | Knowledge scores regarding complications and management of seizures were significantly improved after the curriculum (p < 0.05). Residents reported more confidence in management after the exercise (p= 0.003). Over 90% of residents agreed or strongly agreed that the course was challenging, realistic, and that debriefing their performance was helpful. There was significant improvement in two of the four teams between first and second scenarios stratified by rater (Cochran-Mantel-Haenszel test). | Good/#151/ Medical simulation of sentinel events from the epilepsy monitoring unit (EMU): Validation of a team training curriculum. |
| Niazi, et al. (2019) | Interventional study | Simulation | 2 | Clinical Neurology, Brain death | 10 Neurology residents | No comparison group | Abstract | *Neurology* | Step 1: Pre-curriculum survey. Step 2: Self reading. Step 3: Faculty driven lecture. Step 4: Simulation based supervised brain-death examination followed by breaking the news Step 5: Gift of life staff sessions on organ donation. Step6: Grand round by an invited external expert. Step7: To help us improve your journal readin | Simulation based brain death examination is an effective, feasible and practically important curriculum for neurology residents to not only improve their short comings in this subject but also increase their confidence in performance and communication with family. Statistical significant improvement noted in pre and post test in knowledge and comfort with brain death. | Good/#1595/ Brain death exam and breaking the news; simulation based training for neurology residents; a need for standardization. |
| Douglas, et al. (2017) | Interventional study | Simulation | 2 | Clinical Neurology, brain death | 12 Neurology residents | No comparison group | Abstract | *Neurology* | Intervention involved didactic teaching of clinical and technical aspects of brain death diagnosis as well as effective communication skills with role-playing exercises related to family discussion. Then, a post-intervention assessment included a repeat questionnaire, brain-death simulation and family discussion. | There were 12 participants in the analysis. Statistically-significant differences (p<0.05) were found between pre- and post-intervention scores across all areas of evaluation, including clinical assessment (45.7% to 73.3%), apnea test (55.2% to 90.8%), and verbal communication (48.1% to 73.8%). | Good/#978/ Simulation-based training in brain death determination incorporating family discussion: An update on an ongoing project. |
| Strasser, et al. (2017) | Interventional study | Simulation | 2 | Clinical Neurology, brain death | 153 medical students | No comparison group | Abstract | *Neurology* | Students reviewed medical data, obtained histories and performed the indicated examinations on a mannequin. The actors and preceptors for the discussion groups were provided scripts to ensure specific EPA topics were covered. Two weeks later, students took the questionnaire. Feedback from students was provided by written comment to preceptors. | A total of 153 students completed the simulation and quiz; 145 students, 95%, accurately answered all 5 questions, indicating an expert level of understanding. Five students missed one question and two students missed two questions each. The majority of student feedbacks reported that the simulation improved their understanding of brain death and their proficiency performing the neurologic exam. | Good/#982/ Brain death determination: Addressing the Concept at the Medical Student Level to Ensure Competency and Consistency in Practice. |
| Legault, et al. (2018) | Interventional Study | Simulation | 2 | Clinical Neurology | Neurology residents | No comparison group | Abstract | *Stroke* | Achievement of learning goals was measured with a pre- and post- multiple-choice quiz. Residents submitted anonymous written feedback that the authors analyzed with thematic coding. | Between July 2016 and July 2017, 22 junior adult and pediatric neurology residents completed stroke code simulation. Quiz grades improved from 67.5% to 78.3% after the simulation. Common feedback themes reference comfort with code logistics, imaging order entry, team member roles, benefit of realistic scenarios, and desire for more scenarios. The residents perceived simulation would relieve the stress of stroke call. The use of simulation was overall highly valued. | Good/#2010/ Neurology resident education with acute stroke simulation improves code readiness. |
| Pirmohamed, et al. (2016) | Interventional study | Simulation | 2 | Clinical Neurology | Neurology residents | No comparison group | Abstract | *Neurology* | Participant’s medical knowledge was assessed via written test before and after completing the curriculum. | The test showed a 57% increase in competency after completing the program. Post curriculum evaluations revealed that 95% of participants found the exercise to be useful and 97% thought this would be useful in their future neurological practices. | Good/#1383/ An interactive simulation based curriculum for the use of peripheral nerve blocks in headache management. |
| Johnsen, et al. (2015) | Interventional study | Simulation | 2 | Clinical Neurology | Neurology residents | No comparison group | Abstract | *Neurology* | Residents completed surveys and multiple-choice exams before and after simulation to assess confidence and knowledge of acute stroke management. | After simulation training, residents felt more comfortable with their knowledge base and ability to manage acute strokes. Residents enjoyed the experience and wanted more simulation sessions. Medical knowledge as assessed by pre and post intervention multiple-choice test scores improved though it was not statistically significant. | Good/#314/ Improving resident performance in acute stroke management through simulation based training. |
| Poblete, et al. (2018) | Interventional study | Simulation | 2 | Neurological emergencies, ICP crisis | N/A | No comparison group | Abstract | *Neurocritical care* | Participants completed an objective knowledge-based test pre and post-simulation, as well as subjective surveys utilizing 5-point Likert scale scores to assess program efficacy. | A 23% improvement in test scores after simulation and debriefing was observed (p=0.015). Surveys suggested improved comfort in the medical management of ICP crisis and improved comfort in EVD troubleshooting (p=0.033). All participants preferred simulation to conventional didactics. | Good/#1104/ Neurosimulation as an educational tool for the management of ICP crisis: Effective, understudied and underutilized |
| Johnson, et al. (2017) | Interventional study | Simulation | 2 | Neurological emergencies, Stroke | 26 medical students, 65 nurses | No comparison group | Abstract | *Stroke* | Using a quantitative descriptive one group pretest/posttest design, acute stroke care (14 items), TeamSTEPPS knowledge (14 items) and attitudes toward IPE (16 items) were assessed. | Improvement was seen in the cognitive assessment (p<0.0001 for composite score) and each affective item (p<0.0001) after SBME. Psychomotor scores improved (p<0.01) in most items on the team performance checklist and improved for 5 items on the stroke task checklist. | Good/#748/ Simulation based medical education in interprofessional education: Acute stroke management model. |
| Novara, et al. (2013) | Interventional study | Simulation | 2 | Neurological emergencies, Stroke | 49 participants (13 PGY1, 21 PGY2, 7 PGY3, 8 PGY4-6 | No comparison group | Abstract | *Annals of Neurology* | Pretest eval, then after simulation, trainees completed a post‐test and 2‐month knowledge retention. | The test scores improved significantly between the pre‐test and post‐ test from 58% ± 16% to 88% ± 12%, p <0.001. There was reasonable retention of knowledge on the 2‐month follow‐up assessment with average score of 70% ± 15%, p = 0.004. There was no significant difference in pre‐test scores between PGY1, 2, or 3 (p = 0.79) nor was there a difference between residents (PGY1‐3) and fellows (PGY4‐6), p=0.24. | Good/#2013/ Time is brain for kids too: Using simulation as a tool in pediatric stroke education. |
| Albin, et al. (2019) | Interventional Study | Simulation | 2 | Neurological emergencies | 20 neurology residents | Simulator mannequin group vs. Standardized patient | Abstract | *Neurology* | All residents completed a 40 question multiple-choice test on management of neurologic emergencies and a survey about their confidence handling 15 neurologic and 6 non-neurologic emergencies before and immediately after the simulation sessions. Finally, all residents answered items about the educational quality of their simulation sessions. | When combined, both resident groups had statistically significant higher knowledge scores after their training sessions (pre: 49% vs post: 72%, p<0.001). There was no statistically significant difference in the increase between the two groups (average of 23% increase in both groups). There was also a statistically significant increase in confidence among all residents after training (p<0.001). However, there was no significant difference of the increase in confidence scores between the two groups (SP group = 11.78 points vs. mannequin group = 11.30 points, p=0.865). | Good/#1593/ The use of standardized patients versus mannequin-simulation for training in neurologic emergencies how real is real enough A pilot study. |
| Wong, et al. (2018) | Interventional study, pilot study | Simulation | 2 | Clinical Neurology | 40 Neurology trainees | No comparison group | Abstract | Neurology | The course was taught by a child neurology resident, adult neurology resident, and adult neurology professor. Topics were accompanied by pre/post MCQ tests, and attitude questions using Likert scales. | 40 residents and attendings from pediatrics, internal medicine, psychiatry, and neurosurgery participated in the course. 30 participants completed pre/post test assessments. 41.7% reported having received less than one month of neurology training prior to the course. Average improvement between pre/post test scores was 26.7%. Reported confidence (measured on Likert scale) in managing patients with a particular neurologic condition increased in all subjects taught. | Good/#1448/ Developing a child neurology training program in Cambodia: A pilot study. |
| Gill, et al. (2015) | Interventional study, pilot sudy | Simulation | 2 | Neurological emergencies, Stroke | 2nd year neurology residents | No comparison group | Abstract | *Stroke* | Residents completed an affective survey, pre- and post-test cognitive assessment and debriefing with feedback, as well as real time checklist and review of videotaped assessment of their performance. | Subjects showed a 16.1% improvement in the cognitive assessment from week 1 to week 3 (p=0.02). The affective survey showed residents were moderate to highly confident in their ability to perform a history and physical prior to participation, yet they had low confidence utilizing the NIHSS and managing medications for acute stroke in the ED prior to participation. | Good/#281/ Simulation based medical education for incoming neurology trainees to improve hospital stroke emergency performance |
| Zaika, et al. (2017) | Interventional, feasibility study | Simulation | 2 | Neuroradiology | Residents and medical students | No comparison group | Abstract | *FASEB Journal* | Residents and graduate students were given practice diagnostic angiography and were subsequently tested on a right middle cerebral artery aneurysm case, repeating over 8 sessions. Participants were also administered a mental rotations test (MRT) and grouped into MRT groups to identify performance differences. | We have identified a significant self-guided reduction in spatial errors by the participants over 8 sessions. Further investigation revealed a negative change in error frequency for major trajectory deviations. This allowed us to categorize vessels that, although less frequent in erroneous access, were creating the most difficulty for the trainee and most potential harm to patients. Assessing MRTs, we found that high MRT individuals performed much better than low MRT individuals at the start of the study, however, both groups plateaued at a similar performance level by the 8th session. | Good/#966/ Effect of simulation-based cerebral angiography training on navigational error in novices. |
| McVicar, et al. (2015) | Interventional, investigational study | Simulation | 2 | Clinical Neurology, Lumbar puncture | 26 medical students | Control vs US group (activated needle-tracking system) | Abstract | *Reg Anesth Pain Med* | The participants were assessed for success rate, technical aspects of block performance, and certain behaviors that could compromise the quality of the block. Learning curves were developed to assess competence. | The needle guidance group reached competence more often. This group had fewer attempts and quality-compromising behaviors than did those using conventional ultrasound. | Good/#3144/ Novice performance of ultrasound-guided needling skills: effect of a needle guidance system. |
| Capampangan, et al. (2013) | Interventional, investigational study | Simulation | 2 | Neurological emergencies | 4 subjects | No comparison group | Abstract | *Neurology* | A pre-test of 8 items was given before simulation. Items assessed the subject's comfort ability in status epilepticus management, knowledge of differential diagnosis of status epilepticus, history taking, coma examination, neuroimaging interpretation, status epilepticus algorithm familiarity, communication skills, and knowledge of certain IV anti-epileptic medications, with a 1 (strongly disagree) to 5 (strongly agree) scale. Subjects performed the simulation with a high fidelity mannequin. After simulation and debriefing, subjects were then given a post-test. Paired t-test assessed pre/post test score differences. McNemar test assessed strongly agree pre/post test percentage differences. | Prior to simulation training, none of the four participants indicated strong agreement with any of the eight items assessed. Management, coma examination, neuroimaging interpretation, and communication skills had the highest scores prior to training, while algorithm familiarity and coma examination had the highest scores after training. Mean scores improved for all items except neuroimaging interpretation. The greatest improvement was observed for algorithm familiarity, management, history taking, and knowledge of IV medications. Three of the four participants had improved scores for management, algorithm familiarity, and knowledge of IV medications. Two of the four participants improved for the other items except neuroimaging interpretation. | Good/#1248/ Simulation based training for status epilepticus. |
| Wadhwa, et al. (2017) | Interventional, pilot study | Simulation | 2 | Neurological emergencies, Stroke | 31 neurology residents | No comparison group | Abstract | *Stroke* | Pre & post simulation survey, SP comments and debriefing was done for each scenario. | Residents reported 100 % satisfaction with quality of demonstrations and hands-on learning experience.The accuracy and timing of decision making - IV thrombolytic, No Thrombolytic and catheter based reperfusion was significantly better to historic control and pre and post simulation competency. The decision making also improved from 1st to the 5th case scenario. Significant improvement was also seen in patient interaction, utilization of NIHSS and ABCD2 score in decision making, indications and contraindications to thrombolytic, utilization of resources including CT & CTA, CT perfusion and MRI of brain, door to needle time and consulting Neurointerventionist. | Good/747/ Stroke simulation improves resident confidence in acute stroke/TIA management |
| Lin, et al. (2012) | Interventional, prospective study | Simulation | 2 | Clinical Neurology, cranial nerves | 53 medical students, 9 residents, 7 physicians | Compared residents, medical students, and physicians | Abstract | *Bio-Algorithms Med-Syst.* | Goal is to evaluate the responses from medical students, residents, and clinicians using the Neurological Examination Rehearsal Virtual Environment (NERVE), a cranial nerve (CN) exam simulator. | There were no statistically significant differences in measures related to the actual performance of the exam, the controller, overall benefit of the experience, use of technology or satisfaction with the technology. Even with technical limitations, overall medical student's reported NERVE having educational value. Residents had the lowest rate of correct CN identification, indicating they could be the group that most benefits from repeat exposure to CN exams. Medical students and clinicians were the best groups at identifying the correct deficit for our simulation. | Good/#4299/ User Response to the Simulation of a Virtual Patient with Cranial Nerve Injury. |
| Capampangan, et al. (2012) | Investigational study | Simulation | 2 | Neurological emergencies, Stroke | 5 neurology residents | No comparison group | Abstract | *Neurology* | After simulation and debriefing, subjects were then given a post-test. Paired t-test assessed pre/post test score differences. McNemar test assessed strongly agree pre/post test percentage differences. | Simulation improved post test scores on all 8 items. Simulation improved learning outcomes and skills when all 8 item scores were averaged (P=.03). Comfort ability of identifying acute ischemic changes/ruling out ICH on CT (P=0.02), knowledge of inclusion/exclusion criteria of tPA (P=0.02), and knowledge of tPA (P=0.05) improved after simulation. The percentage of strongly agree scores per item were higher in the post-test. However, only knowledge of tPA and its inclusion/exclusion criteria achieved borderline significance (P=0.08). | Good/#136/ Simulation based training for acute stroke alerts. |
| Agarwal, et al. (2014) | Observational, feasibility, interventional study | Simulation | 2 | Neurological emergencies | 10 neurology residents | No comparison group | Abstract | *Neurology* | Learning objectives were assessed using crisis resource management (CRM) assessment tools including identification of key actions (0=no, 1=with prompt, 2=never), Ottawa CRM checklist, and knowledge based pre- and postintervention tests. | Acute stroke case: mean key action scores (maximum score 28) were 17.8±1.5 & 16.4±2.9, difference in gain on post-test scores were 0.32±0.3 & 0.2±0.3 after simulation and didactics interventions respectively. ICP crisis case: mean key action scores (maximum score 24) were 16.4±4.6 & 17.3±0.6, difference in gain on post-test scores were 0.14±0.19 & 0.13±0.11, for simulation and didactics groups respectively. Status epilepticus case: mean key action scores (maximum score 38) were 31.8±3.4 & 28±3.9, difference in gain on post-test scores were 0.2±0.24 & 0.28±0.4 after simulation and didactics interventions respectively. Median CRM score were 6 & 4 for stroke and ICP crisis cases, 6 & 6 for status epilepticus cases when comparing SBL and didactic groups. There were no statistically significant differences found between groups for either of the pre-specified outcomes. | Good/#912/ High-fidelity simulation versus traditional didactic techniques for teaching neurological emergencies to neurology residents: A feasibility study. |
| Gupta, et al. (2017) | Randomized, interventional trial | Simulation | 2 | Clinical Neurology, ophthalmology | 48 neurology residents | Simulation group vs control group | Abstract | *Neurology* | Nonparametric Mann-Whitney test was used to assess for significant differences (p < 0.05) in primary outcome measures (post-intervention changes in fundoscopy test knowledge score, skills score and total score) and secondary outcome measures (post-intervention changes in each of the five survey items score) between control and test groups. | Test group, compared to control group, had significantly higher increases in skills and total scores while knowledge score increased non-significantly for both groups (figure 1). Similarly, test group had significantly higher increases in three of the five self-reported survey items while the scores for remaining two items increased non-significantly for both groups | Strong/#989/ A randomized education research trial of fundoscopy training methods in neurology residency. |
| Frallicciardi, et al. (2015) | Interventional study | Simulation, eLearning | 2 | Neurological emergencies, Stroke | Residents | No comparison group | Abstract | *Western Joural of Emergency Medicine* | Learners then participate in a small group stroke simulation session consisting of 6 cases of neurologic catastrophes and interactive post case debriefing. Cases are original and emphasize the time sensitivity of an accurate diagnosis and treatment plan. | The effectiveness of the curriculum has been measured over 2 years (n=36). Time to Head computerized tomography (CT) and tissue plasminogen activator (t-PA) orders in the sim cases significantly improved. Initially time to CT order was 7.8 minutes into the case (SD1.8, 95% CI 1.4), which improved to 3.42 minutes(SD 2.3, 95% CI 1.8) by the end of the sessions. The residents also ordered t-PA in ischemic strokes 4.2 minutes faster (CI:[1.97,6.5]). The NIH scoring of the patients was very accurate (SD 0.06) in all cases. The self-efficacy score improvement over the course was significant at 1.6 (CI:[1.9,1.25]). On a multiple choice post-test, scores were on average 22.25 percentage points higher (95% CI:[-29.0-15]). | Good/#343/An innovative approach to emergency medicine stroke education utilizing simulation and e-learning improves time to diagnosis and treatment: A pilot simulation program. |
| Gago, et al. (2016) | Feasibility study | Simulation, group learning | 2 | Neurological emergencies | 43 1st year neurology residents | No comparison group | Abstract | *European Journal of Neurology* | Pre/post test, Participant rating, competency | High overall rating by participants, higher post test scores after course. | Good/#1401/ iNeurology: An introductory course for neurology residents |
| Omron (2020) | Interventional study | Smart phone app, eLearning | 2 | Clinical Neurology | 21 learners (3 medical students, 3 ER physicians, 1 PA, and 14 residents) | No comparison group | Abstract | *Academic Emergency Medicine* | Pre and post-education study used an iPhone application (aVOR) to educate and assess the performance of clinicians in maneuvers essential for diagnosing BPPV. | Initially, eleven learners correctly identified posterior canal BPPV. After, twenty of twenty-one correctly diagnosed posterior canal BPPV (p=0.007). Nine participants initially diagnosed horizontal canal BPPV correctly. After, nineteen participants were able to diagnose horizontal canal BPPV (p=0.004) accurately. Before, fourteen participants diagnosed normal. After, nineteen participants diagnosed normal (p=0.025). Nine participants submitted a post-intervention survey and responded that this program wa | Good/#1910/ A smart phone application improves performance of the dix-hallpike and supine roll maneuver |
| Schanandore, et al. (2017) | Interventional study | TBL (team-based learning) | 2 | Neuroanatomy | 179 medical students | No comparison group | Abstract | *FASEB Journal* | A post-test was given to assess the impact of TBL on student learning retention. To assess student perceptions of TBL, a survey was administered after the laboratory unit exam. | The results suggested that students achieved higher mean posttest scores (70.17±1.40%, n =177) two weeks after the TBL module comparing to the pretest scores (43.08±1.40%, n=177; p < 0.001). Comments from the observers indicated that TBL promoted student participation, team work, and peer teaching. The results of the student survey showed that most students believed that TBL helped them understand laboratory content (82.12%), correct misconceptions (78.78%), develop information synthesizing skills (67.60%), and prepare them for the laboratory examination (74.86%). The survey also indicated that over 80% of the students have a positive attitude toward team working and collaboration. | Good/#770/ Teambased learning in the neuroanatomy lab of an undergraduate human anatomy and physiology course-a lesson study. |
| Tan, et al. (2016) | Modified cross-over study | Team Based learning (TBL) | 2 | Clinical Neurology | 179 medical students | TBL group vs interactive lectures group | Abstract | *Neurology* | We analyzed the differences in SCT scores between groups using the unpaired T-test. | Mean SCT scores in NL for students receiving TBL were higher compared to interactive lectures (64.8% vs 61.7%, mean difference 3.1% ,95% CI 0.7-5.5%, p=0.013). Effect size was 0.37. Mean SCT scores in NE, however, were not significantly different between groups (66.6% vs 67.0%, mean difference 0.4%,95% CI -2.3% -3.1%,p=0.75). | Good/#1377/ Does team-based learning improve clinical reasoning in neurology? |
| Weeks, et al. (2019) | Observational, interventional study | VR | 2 | Neuroanatomy | 16 medical students | No comparison group | Abstract | *Med Educ* | Students completed a multiple-choice neuroanatomy test (five multiple-choice questions) before and after the session and provided detailed feedback through structured and free-response questions. | Mean score increased significantly between the pre and post quizzes (paired sample t-test; p = 0.00053). Student rating of their examination readiness increased significantly (p of 0.00354). The average rating of AR as compared with other resources was 4.21 (4 = better than other resources; 5 = best resource I’ve used). All students agreed AR is ‘high yield’ and 14/16 agreed AR anatomy modules should be formally incorporated into the curriculum. | Good/#3642/ Enhancing neuroanatomy education with augmented reality. |
| Fahy, et al. (2020) | Interventional, observational study | eLearning | 2 | Clinical Neurology, EEG | 24 neurology residents | Interventional group vs average scores | Abstract | *Neurological Sciences* | Total percent correct for each scenario and average percent correct for all scenarios were calculated and correlated with most recent In-training Examination (ITE) and United States Medical License Examination (USMLE) scores. | Neurology residents’ mean percent correct scenario scores ranged from 27.1–86.0% with an average scenario score of 61.2% ± 7.7. We showed a moderately strong correlation r = 0.49 between the ITE and the average scenario score. | Good/#2131/ An online, interactive, screen-based simulator for learning basic EEG interpretation. |
| Pickles, et al. (2020) | Collaborative, feasibility study | 3-D modeling/printing | 1 | Neuroanatomy | Medical students | No comparision group | Abstract | *Clinical Anatomy* | Students used this model to identify anatomical features and illustrate functional areas. Learning activities were designed using these models to move students through Blooms taxonomy of cognitive development-identification of structures, demonstration of knowledge via illustration and finally prediction of clinical outcomes. | Informal student feedback following use of the models and learning activities has been very positive. As replicas of real human anatomy students also reported using the models gave added appreciation of the anatomical variation that can occur between individuals. | Good/#2103/ Using our brains for three-dimensional learning of anatomy. |
| Samalia, et al. (2015) | Exploratory, feasibility study | 3-D modeling/printing | 1 | Neuroanatomy | N/A | No comparison group | Abstract | *Clinical Anatomy* | Each production had input from a clinical anatomist and a member of the technical staff. After initial planning, we ended up making miniatures of the models and then larger or same size as in the living using simple, less-expensive material.  | The outcome is the production of novel teaching modalities, which benefit both the students faced with integrating their anatomy with the clinical context, as well as benefits to the program from strengthening the ties with the clinicians.  | Good/#562/ In-house model construction for clinical anatomy teaching. |
| Eltayeb, et al. (2020) | Interventional study | 3-D modeling/printing | 1 | Neuroanatomy | Medical and dental students, surgical trainees | No comparison group | Abstract | *Clinical Anatomy* | pilot anatomy teaching session using a 3D color-printed cranioplasty skull model obtained from the local hospital's Neurosurgery Department. | The model was utilized in head and neck anatomy sessions taught to both medical and dental students, as well as for anatomy revision for surgical trainees, with encouraging results. | Poor/#2104/"additive manufacturing" in medical education: Marrying cranioplasty with skull anatomy utilizing 3D printing can enhance anatomy learning. |
| Brewer, et al. (2012) | Interventional Study | 3-D modeling/printing | 1 | Neuroanatomy | Medical students | No comparison group | Abstract | *Student Health Technology Information* | Two subsets of health science and medical students were tested individually after being given a group lecture and either a pre- or post-dissection digital lab | Results suggest that exposure to a 3D digital lab may improve knowledge acquisition and understanding by the students, particularly for first time learners. | Good/#3486/ Evaluation of neuroanatomical training using a 3D visual reality model. |
| Pedersen, et al. (2013) | Investigational, pilot study | 3-D modeling/printing | 1 | Neuroanatomy | Medical students | No comparison group | Abstract | *Studies in health technology and informatics* | Develop an interactive 3D learning tool of the internal brainstem anatomy and assess its efficacy on student learning against the classical methods of learning neuroanatomy. | Results reveal that students the amount of learning was equal between both experimental groups. Qualitative results show that students enjoyed interactive learning and warmly welcomed the 3D program. | Good/#1303/ An interactive program to conceptualize the anatomy of the internal brainstem in 3D. |
| Barger, et al. (2015) | Interventional, observational study | Art education, drawing | 1 | Neuroanatomy | Medical students, neurology residents | No comparison group | Abstract | *FASEB Journal* | Collected voluntary survey responses from the students who had used the software. We also collected survey responses from instructors in whose classes the software was provided to the students. | From the survey responses we found students and instructors both had very positive interpretations of the software (Student mean on five-point Likert scale=4.07, Instructor mean on five-point Likert scale=4.43). Students strongly agreed that the software was a valuable learning tool, and many reported a desire to see more guided drawings in other basic science courses (Student mean on five-point Likert scale=4.08). Among students who self-reported as visual learners, the use of drawings had a positive response, but even among students who did not self-identify as visual learners, the software was positively received. | Good/#301/ A survey of student use of a novel software tool for teaching neuroanatomy, draw it to know it. |
| Filipovic, et al. (2017) | Interventional, feasibility study | Art education, Flipped classroom, drawing | 1 | Neuroanatomy | N/A | No comparison group | Abstract | *FASEB Journal* | Students watch brain dissection movies and drawing tutorials, followed by quizzes and assessments online. Subsequently, during class meetings, we discuss about the role of nervous system regions using case studies that illustrate common neuropathologies | Introductory online drawing tutorials help students to visualize three dimensional relationships of nervous system regions, and improved student engagement during class. However, when students were assigned to draw the complicated neuronal pathways before in class lecture, their cognitive skills and engagement were not improved. | Good/#968/ Using flipped model and drawing tutorials to teach neuroanatomy in graduate certificate program in intraoperative neuromonitoring. |
| Jonas, et al. (2019) | Feasibility study | eLearning | 1 | Clinical Neurology, Neurophysiology | 189 medical students | No comparision group | Abstract | *Acta Physiologica* | Participant satisfaction | satisfaction evaluated by an auto-questionnaire was high (4.18 /5 ± 1.18 in average) | Good/#1813/ Using a cloud-based learning platform in order to improve physiology teaching |
| Severson, et al. (2015) | Interventional study | eLearning | 1 | Neuroanatomy | N/A | No comparison group | Abstract | *FASEB Journal* | The learning tool is available online for student use and facilitates learning neuroanatomical structures, structural relationships, significant morphological and functional features of the human central nervous system, and the clinical relevance of the neuroanatomical structures. | Student comments indicate that this is an efficient and effective way to learn the neuroanatomical and functional aspects of the nervous system available online at the student's convenience. The computer-assisted learning tool accomplishes our neuroscience laboratory goals. | Good/#300/ Developing an HTML5 neuroanatomical learning tool for the computer, tablet and smartphone. |
| Chan, et al. (2012) | Interventional study | eLearning | 1 | Neuroanatomy | Medical Students | No comparison group | Abstract | *Irish Journal of Medical Science* | An interactive animation follows, providing perceptual continuity of the impulse through the peripheral and central nervous systems. Interactive images, anatomical and clinical information, in addition to voice-over material, are included in the package to assist the overall learning experience.  | A pilot resource has been developed for integration into the undergraduate Medicine core curriculum to assist neuroanatomy teaching. It is anticipated that this tool can be used to enhance the overall learning experience and assessment of neuroanatomy. | Good/#198/ Conquering 'neurophobia': Interactive animation for neuroanatomy teaching. |
| Wells, et al. (2014) | Interventional study | eLearning | 1 | Clinical Neurology – Sleep medicine | 9 neurology residents | No comparison group | Abstract | *ProQuest* | Study aims to examine a possible solution to this gap by integrating a supplemental sleep education program that residents can complete via e-learning on mobile devices. The research goal is examining the educational experience of neurology residents as they participate in a supplemental sleep medicine e-learning module. | The findings of this research support the idea that supplemental education on sleep disorders completed through electronic learning (e-learning) and mobile learning (m-learning or mlearning) platforms provides a portable and acceptable solution for neurology residents to gain critical knowledge and skills in sleep medicine. | Good/#2359/ Mobile Learning in Medical Education: A Case Study through the Lens of Sleep Education. |
| Vadlamani, et al. (2019) | Interventional study | eLearning | 1 | Clinical Neurology | Neurology residents | No comparison group | Abstract | *Neurology* | Users completed surveys, and semi-structured interviews were conducted, double-coded, and analyzed. | 8/8 housestaff completed all modules and were interviewed, and 6/8 completed the survey. On the survey, all users strongly agreed that the modules were a worthwhile use of time and that they would recommend them to other residents. All users agreed or strongly agreed that the modules helped them understand both basic and difficult concepts in movement disorders. | Good/#1590/ An interactive, video-based, online curriculum in movement disorders for neurology housestaff: A pilot study. |
| Lavette, et al. (2020) | Interventional study, pilot study | eLearning | 1 | Clinical Neurology | Neurologists, neurology trainees, and medical students | No comparison group | Abstract | *Neurology* | Usage was assessed by quantifying course enrollment and completion rates; feasibility by quantifying the cost and time required to design and release a module; appeal by user satisfaction scores; and effectiveness by self-reported change in practice. | A total of 5,130 NeuroBytes member enrollments (1,026+551/month) occurred from January 11–May 28, 2019 with a median of 588 enrollments per module (interquartile range, 194–922) and 37% course completion. The majority of viewers were neurologists (54%) followed by neurologists in training (26%) and students (8%). NeuroBytes took 59 hours to develop at an estimated $77.94/hour. Of the 1,895 users who completed the survey, 82% were “extremely likely” or “very likely” to recommend NeuroBytes to a colleague and 60% agreed that the depth of educational content was “just right.” Only 29% of viewers responded that NeuroBytes would change how they managed many of their patients. | Good/#2071/ Neurobytes: A new rapid, high-yield, nationwide e-learning platform for continuing professional development in neurology |
| Severson, et al. (2013) | Interventional, feasibility study | eLearning | 1 | Neuroanatomy | N/A` | No comparison group | Abstract | *FASEB Journal* | Gross images of intact and dissected brains, sections of the whole brain, brain stem and spinal cord, and MR images are included. Neural structures to be identified are listed on the right-hand side of the computer screen. | Data from student surveys and comments indicate that this is an effective way to learn the anatomical and functional aspects of the nervous system that is available on a 24/7 basis. With less instructional laboratory time, limited laboratory materials, and fewer faculty available for laboratory instruction, the computer-assisted learning tool accomplishes our educational goals and is enthusiastically accepted by the students. | Good/#1267/ Learning human neuroanatomical structure and function using a computer-based learning tool. |
| Woodward, et al. (2011) | Interventional, feasibility, investigational study | eLearning | 1 | Neurological emergencies, Stroke | Physicians, residents | No comparison group | Abstract | *International Journal of Stroke* | During design, implementation and completion, users from a range of centres evaluated the prototype. Where possible, feedback was integrated using iterative design | Health-care professionals including postgraduate trainees, Stroke SpR/Consultants, neuro-radiologists, and acute medical doctors indicated strengths and weaknesses of the prototype. The evaluation focused on clinical content and interface. The scenario format, design and integration of media elements were well received, and were considered relevant and suitable for independent learning. Weaknesses included lack of formative assessment and mismatched content level, which may limit the learning experience. | Good/#98/ E-Learning framework for stroke. |
| Smith, et al. (2015) | Interventional study | eLearning, ipad/tablet | 1 | Neuroanatomy | 185 medical students | No comparison group | Abstract | *FASEB Journal* | Brought together a range of e-learning products and made them accessible via a single portal, available for both mobile and desktop platforms | Results from evaluation (N = 185) revealed a take up rate of 65%. 90% of students who used the resource rated it as very good or good. Students rated the interactive diagrams as their favorite aspect, the discussion board the least popular. Despite the intention being for mobile use 14% of students accessed the package through a tablet computer, the majority were choosing access through their home PC (55%). Results indicate that this intervention was successful in supporting learning. | Good/#296/ Shaping neuroanatomy education in medicine: Implementing an Ipad friendly ebooklet to support practical based learning. |
| Hersheson, et al. (2011) | Interventional study | eLearning, social media network | 1 | Clinical Neurology | N/A | No comparison group | Abstract | *European Journal of Neurology* | Use of a dedicated low-bandwidth social networking portal (www.medicineafrica.com), which aims to provide supplementary ’bedside’ teaching to medical students and interns based in remote areas with limited access to resources and clinical support. | The teaching program includes modules on neurological infectious diseases and stroke - illnesses with high prevalence and mortality across the developing world. The impact of this program has been evaluated through questionnaires and focus groups with all interns reporting improvements in problem-solving and analytical skills | Weak/#67/ Supporting postgraduate medical education in Africa: Real-time interactive neurology teaching of trainee physicians using a dedicated social-networking portal. |
| Denson, et al. (2010) | Interventional study | eLearning, TBL, role play | 1 | Clinical Neurology, Geriatric Medicine | N/A | No comparision group | Abstract | *Journal of the American Geriatrics Society* | End of course OSCE, participant evaluation of collaboration | Evaluation of interactive rounds showed 69% of the students rated the session “excellent” and the presenter engaging. On-line module evaluation (Neurology N=176), rated the module “very helpful/helpful” (60%), noting the mode of learning to be “straight-forward, concise, and useful for future clinical practice.” The Neurology end-of-clerkship OSCE demonstrated improved scores and learning retention by students who completed the on-line module | Good/#477/ Don't go it alone: A multispecialty collaborative to teach geriatrics in third year clinical specialties |
| Dominguez, et al. (2018) | Interventional, observational study | eLearning, video based learning | 1 | Clinical Neurology | 135 medical students | No comparison group | Abstract | *The Journal of Teaching and Learning Resources* | Feedback was obtained by surveys of students and faculty lecturers and from student focus groups and faculty. Student performance on the end-of-clerkship examination was analyzed | 135 students participated in the curriculum, and 56 students (41.5%) responded to the surveys. Most students agreed or strongly agreed that the new curriculum enhanced their learning and promoted their sense of responsibility in learning the content. Faculty agreed that this pedagogy helped prepare students for class. Most students watched the entire video-based lecture, although there was a trend toward decreased audience retention with longer lectures. There were no significant changes in performance on the end-of-clerkship examination after implementation of just-in-time teaching. | Good/#1432/ A Neurology Clerkship Curriculum Using Video-Based Lectures and Just-in-Time Teaching (JiTT). |
| Krebs, et al. (2014) | Interventional study | Flipped classroom | 1 | Neuroanatomy | N/A | No comparison group | Abstract | *FAESB Journal* | A Readiness Assessment Test (RAT) at the beginning of the session gauges student understanding of the material; lab time is then used to address areas of weakness as well as to apply knowledge to clinical cases - a core focus of each lab. | Evidence suggests that this approach can make the classroom experience more engaging for both faculty and students. | Good/#899/ Flipping the neuroanatomy labs: How the production of high quality video and interactive modules changed our approach to teaching. |
| Bauman, et al. (2019) | Interventional study | Flipped classroom | 1 | Clinical Neurology | 37 neurology residents | No comparison group | Abstract | *Neurology* | Participants were asked to complete a survey before and after the session. The survey assessed participants’ self-perceived active learning, FC efficacy, and preference for FC through a series of 13 questions rated on a scale of 1 to 5 with 5 being the most positive rating | 37 survey responses were recorded. The average responses on the 5-point scale were 4.30 (95% CI 4.11 to 4.49) for questions regarding active learning, 4.34 (95% CI 4.22 to 4.46) for questions regarding FC efficacy, and 4.18 (95% CI 4.03 to 4.35) for questions regarding FC preference. The proportion of positive responses, defined as ratings of 4 or 5, were 93%, 92%, and 91% for student responses versus 70%, 87%, and 63% for resident responses for questions regarding active learning, FC efficacy, and FC preference respectively. | Good/#1594/ Flipped classrooms as a learning tool for neurology noon conference curriculum. |
| Morawo, et al. (2020) | Interventional Study | Flipped classroom, eLearning | 1 | Clinical Neurology | 38 3rd year medical students | No comparison group | Abstract | *Neurology* | The final quiz consisted of 20 interleaved clinical vignettes delivered via the jeopardy feature of PollEverywhere. Students were placed in groups competing for the highest score awarded automatically for speed and accuracy. A survey was then conducted on level of satisfaction and perception of relevance | 100% were satisfied or highly satisfied; 89% felt it was relevant or very relevant to their shelf exam; 89% felt it was relevant or very relevant to preparation for the USMLE; 100% indicated that the session enhanced their clinical skills; and 97% felt the depth was appropriate. | Good/#2090/ Assessing impact of evidence-based pedagogic techniques in resident-led neurology didactics |
| Dhyani, et al. (2020) | Interventional study | Gaming | 1 | Clinical Neurology | Neurology trainees | No comparison group | Abstract | *Neurology* | At the end of the game, each player completes a questionnaire with closed and openended questions for analysis. | The activity was well received by students and residents. The study included individuals with different levels of gaming experience. Overall, participants felt that the game was effective in reinforcing the concepts learned in class. They also found the game enjoyable and easy to play. The majority of participants also expressed that they wanted games to be included in most of their courses. | Good/#2093/ A stroke of genius: Using gaming to reinforce learning in neurology education |
| Rueff-Barroso, et al. (2018) | Interventional, feasibility study | Gaming | 1 | Neuroanatomy | Medical students | No comparison group | Abstract | *FASEB Journal* | After participating, students answered to a quiz related to their impressions about the game. | The game was useful for self-assessment (90.6%), colors made the activity more fun (100%), the game was fun to play (96.9%), students would like to have more classes like this (90.6%), the game increased the stimulus to study for the test (96.9%), students found the method effective as a review class (96.9%), students felt motivated to study neuroanatomy after playing the game (87,5%), and the game stimulated interaction between the students (90.6%) and student/professor (93.8%). The adjectives used more often for the game were amusing (14.3%), dynamic (13.2%), interesting (13.2%) and stimulant (11%). We observed that 50% of the students increased their grades after playing the game. | Good/#1440/ The challenge of brains: A ludic and amusing game useful to review neuroanatomy for undergraduate students. |
| Leach, et al. (2013) | Interventional study, investigational | Smart phone app | 1 | Clinical Neurology | Medical students | No comparison group | Abstract | *Journal of Neurology* | The number and nature of the questions were compared in those sessions with and without the live text facility. Students and speakers took part in a survey to evaluate their experience of the 'live text' experiment. | In 4 hours of lectures with text facility, 86 texts were received; these comprised 56 requesting factual clarification or expansion, 28 jokes, and 1 practical point about the lecture hall. Additionally, 2 oral questions were posed after the lectures. After 4 hours of lectures without text facility, there were 9 questions posed to the individual speakers, all requesting factual clarification. These oral questions and their answers were not shared with the rest of the group. After exclusion of jokes, the number of questions posed to lecturers where live texting was offered was found to be significantly greater than the number posed where no live texting was available (p=0.03, Mann Whitney U test). Students' and speakers' survey responses confirmed that they found the text-questioning to be enjoyable and worthwhile. | Good/#791/ The joy of text; Interactive lectures in the electronic age. |
| Biesalski (2016) | Interventional, observational study | Podcasts | 1 | Clinical Neurology | 100 medical students | No comparison groups | Abstract | *Der Nervenarzt* | In addition to questions about the listening experience and intelligibility, the students were asked to give an individual evaluation of the different topics and to express their opinion in a free text field. | A total of 100 medical students participated. They listened to the podcasts in particular to prepare themselves for medical examinations (47.4%) and because of a special interest in neurology (26.3%). The different podcasts were mainly evaluated as 'good' or 'very good'. Of the students 76.8% wanted to listen to the podcasts again and 93% planned to recommend the podcasts to friends. Only the length of some of the podcasts as well as technical faults were criticized and should be improved.  | Good/#2675/ Neurologie-Podcasts: Ein Projekt von Studierenden für Studierende = Neurological podcasting A project by students for students. |
| Sun, et al. (2015) | Interventional, comparison study | PBL  | 1 | Clinical Neurology | Medical students | PBL group (30 students) vs traditional group (30 students) | Abstract | *Medical Sciences and Bioengineering* | The students’ behaviors and test scores were observed and compared statistically | The results showed that the students’ learning enthusiasm, self-evaluation, and interest in neurology practice in the PBL group were significantly higher than those in the traditional teaching group; 98% of the students were satisfied with PBL method; test scores of the students in the PBL group were significantly higher than those in the traditional teaching group (P < 0.05). | Good/#4454/ Application of problem-based learning in the clinical practice teaching of neurology. |
| Miles (2018) | Interventional, pilot study | PBL  | 1 | Clinical Neurology | 68 medical students | No comparison group | Abstract | *Neurology* | At the end of the course, students provided feedback on the utility of the videos by responding to 2 statements on a 4-point Likert scale. | Sixty-eight students completed the course and provided feedback. Most either somewhat agreed (32%) or strongly agreed (63%) that the PBL case videos were helpful. About 37% somewhat agreed and 56% strongly agreed additional videos should be developed for other PBL cases. | Good/#1463/ Animated Neurological Exam Videos in PBL Cases |
| Browne, et al. (2016) | Interventional Study | PBL  | 1 | Neurological emergencies, Stroke | Medical students | No comparison group | Abstract | *FASEB Journal* | 26 multiple choice and discussion questions are distributed throughout the module, allowing for formative self‐assessment by the learner. Students may use the module individually, but small groups (3–4 people) are recommended to facilitate discussion. | Meta‐analysis studies of curricula utilizing case‐based learning show that these active learning strategies signicantly increase students’ program evaluation ratings and clinical performance. Our case‐based learning module, developed using a real patient's medical records as well as donor post‐mortem brain images and interactive 3D models, provides an authentic clinical learning experience to supplement basic science training in neuroanatomy and gross anatomy. Small student groups involved in pilot tests reported overall enjoyment of our module, and especially cited the 3D models as positively affecting their experience. | Good/#1358/ A case-based learning module on acute ischemic stroke using donated medical records. |
| Lyerly, et al. (2017) | Investigational study | Role play, simulation | 1 | Clinical Neurology | 19 Neurology residents | No comparison group | Abstract | *Neurology* | A retrospective pre- and post-intervention survey was developed to assess perceived self-efficacy and satisfaction with the intervention. | Participants reported significant improvement in 1) recognizing/responding to emotion, 2) guiding decision-makers in exploring the values and goals of the incapacitated patient, and 3) recommending a treatment plan to match patient goals. All agreed that this or a similar training series should be offered to future residents, and 80% agreed that the training changed their approach to difficult conversations. | Good/#994/ A Four Part Communication Skills Training Curriculum for Neurology Residents. |
| Koblar, et al. (2018) | Interventional study | Role-play, Simulation | 1 | Clinical Neurology, empathy | 62 medical students | No comparison group | Abstract | *Medical Science Education* | All participants completed the Jefferson Scale of Physician Empathy (student version) before and after the role-play exercise and wrote a reflection about their experience. | There was a statistically significant increase in mean empathy scores from baseline to post-participation. Students found the experience valuable and reported increased recognition of the time taken to complete tasks, receiving odd looks and stares, feeling judged, and greater understanding of stigma and of the experiences of people with disabilities. | Good/#5555/ Developing Empathy: Does Experience Through Simulation Improve Medical-Student Empathy? |
| Wu, et al. (2019) | Feasibility, interventional study | Simulation | 1 | Neurological emergencies | 13 neurology resdients | No comparison group | Abstract | *Neurology* | Collected data assess for changes in anticipated comfort/confidence levels and future interest. | Prior to the session, 30% of residents reported either feeling not comfortable or having never treated neurological emergencies (likely due to the start of the new residency training year). All residents had received some neurological emergency training through didactic lectures prior to this session, but only 61.5% of residents received hands-on simulation training. Following the session, 90% felt more comfortable treating acute ischemic stroke and 80% with intracranial hemorrhage. Residents found that “being put on the spot” and “going through real-life cases” were the most valuable components of the session. All residents were interested in attending additional sessions. | Good/#1598/ The implementation and assessment of a comprehensive simulation-based curriculum in treating acute neurological emergencies at UC San Diego: Preliminary results and findings. |
| Ajimi, et al. (2014) | Intervention study | Simulation | 1 | Neurological Emergencies | 38 total 5th year medical students | No comparison groups | Abstract | *Neurocrit Care* | Multiple choice pre and post tests | Average scores of the MCQ before and after the training were 4.13 (95%CI: 1.32 í 6.95) and 7.42 (95%CI: 4.98 í 9.86). A significant difference was observed in these two averages (p < 0.05). | Good/#934/Effect of advanced coma evaluation and care for medical education: A proposal of a novel training system for neurological emergencies |
| Chen, et al. (2019) | Interventional study | Simulation | 1 | Clinical Neurology, Brain death | 13 critical care fellow (1 neurology) | No comparision group | Abstract | *Neurocritical Care* | MCQ Pre/posttest, pre/post curriculum survey of comfort and confidence | There was significant improvement across all measures: self-rated knowledge (5.6 to 7.9, pre-simulation to post-simulation, p= 0.004), knowledge relative to peers (48% to 81%, p=0.002), confidence (4.5 to 8.1, p=0.001) and comfort (4.3 to 8, p=0.001) with performing a brain death exam, and comfort with family discussion (6.5 to 8.6, p=0.01). Test scores improved from 56% to 73% after simulation (p=0.004). | Good/#1519/ Simulation based training improves critical care fellow knowledge and comfort in brain death declaration and surrogate counseling |
| Kvernland, et al. (2020) | Interventional Study | Simulation | 1 | Neurological emergencies, Stroke | Neurology Resident | No comparison group | Abstract | *Neurology* | Participating junior residents completed a six question survey before and after the simulation, which consisted of four multiple choice questions regarding stroke code specifics (e.g. tPA exclusion criteria) and two questions graded on a Likert scale from 1–5 (1=extremely comfortable, 5=not at all comfortable). | Of the 16 participating junior residents, only 31% reported they felt confident running a stroke code prior to the simulation, which improved to 94% after the simulation (mean Likert score= 2.75/5). Whereas only 19% of participants were able to correctly identify tPA exclusion criteria prior to the simulation, 75% correctly identified exclusion criteria on the post-test. | Good/#2077/ Stroke simulation during a neurology bootcamp. |
| Zaika, et al. (2015) | Interventional study | Simulation | 1 | Neuroradiology | 8 trainees (4 radiology trainees, and 8 anatomy students ) | No comparison group | Abstract | *FASEB Journal* | Participants had 8 test sessions to diagnose a cerebral aneurysm with either consistent or alternating practice cases. Subjects then would have 6 sessions to treat the aneurysms by filling them with coils. | Preliminary results show a trend towards speedup, consistent with hypothesis. These findings would have a strong impact on the implementation of novel training protocols in medicine, specifically in angiography, leading to safer, individualized learning modules. | Good/#297/ Effectiveness of simulation-based training in aneurysm diagnosis & coiling in cerebral angiography. |
| Cacic, et al. (2019) | Interventional study | Simulation | 1 | Neurological Emergencies | Neurology residents in a military training program | No comparison group | Abstract | *Neurocritical care* | No clear outcome measurement. | One-week immersive bootcamp early in residency should, therefore, provide a solid knowledge base about management of neurological emergencies for incoming Neurology residents and allow them to consolidate that knowledge leading to safe and effective management of neurological emergencies. | Poor/#2045/ Resident bootcamp for neurological emergencies at a military residency program. |
| Ansari, et al. (2017) | Interventional study | Simulation | 1 | Neurological emergencies | 19 neurology residents (PGY2-3) | No comparison group | Abstract | *Neurology* | The primary outcomes analyzed include: confidence before and after the simulation, and perceived utility of simulation in better understanding management of the condition. Secondary analyses will include: resident performance during the simulation and on quizzes. | Comfort in managing status epilepticus went from 10% to 80%, and among PGY-3 residents went from 89% to 100%, after simulation. Additionally, 100% agreed that simulation was an effective means for learning the management of status epilepticus. Among PGY-2 residents, comfort in managing acute ischemic stroke went from 11% to 100%, while among PGY-3 residents, comfort in managing acute ischemic stroke remained at 100%, after simulation. Additionally, 100% agreed that simulation was an effective means for learning the management of acute ischemic stroke. | Good/#980/ Simulation-Based Medical Education in Acute Neurologic Emergencies. |
| Lehosit, et al. (2012) | Interventional study | Simulation | 1 | Neurological emergencies | 8 neurology residents | No comparison group | Abstract | *Neurology* | Residents participated in a thirty minute pre-simulation briefing on each neurologic emergency/procedure and a hour post-simulation debriefing. The simulations were designed to give the resident learners some familiarity with the various scenarios, diagnoses, management options, informed consent, and the need for escalation of care when appropriate. Resident learners evaluated the simulations with a post-course questionnaire on the benefit of the simulation experience. | All eight resident learners felt that the high fidelity simulation exercises enabled them to have a better understanding in the procedural routine in performing tasks such as lumbar puncture. Resident learners also felt a better understanding in the diagnosis and initial management strategies in treating acute stroke and status epilepticus. The precourse preparation with NIHSS on-line training module and post-course debriefing session were found to be useful by all resident learners and all stated that they would like the course to continue. | Good/#146/ Evaluating the use of high fidelity simulation to introduce and educate incoming neurology resident learners to common neurologic emergencies and procedures. |
| Tai, et al. (2013) | Interventional study | Simulation | 1 | Neurological emergencies, Stroke | Neurology trainees | No comparison group | Abstract | *Stroke* | Trainees communicated with the stroke fellow and nursing regarding the plan of care and placed orders through an electronic medical record in training mode. Debriefing occurred after each scenario. Evaluations were completed and collected. | Trainees had positive experiences and felt more comfortable with the stroke code after the training. On a 1-5 scale, learners rated quality of teaching (average 4.6); learning from the scenario (4.8); overall organization (4.2); facilities (5); and overall evaluation (4.6). | Good/#223/ Simulation-based learning improves neurology resident training in acute stroke care |
| Wendell, et al. (2018) | Interventional Study | Simulation | 1 | Neurological emergencies, Stroke | 23 neurology residents | No comparison group | Abstract | *Neurology* | Residents completed a survey before and after the simulation. | Based on a 5-point Likert scale (1 – least true and 5 – most true), residents reported significantly increased confidence in leading a Code Stroke [mean 2.9 (SD ±0.8) vs. 3.9 (±0.5), p<0.001] and increased preparedness for their next Code Stroke [3.0 (±0.6) vs. 4.1 (±0.7), p<0.001]. Residents were least confident managing coagulopathy in patients with ICH; the simulation also significantly increased their confidence in managing these patients [2.4 (±1.1) vs. 3.5 (±0.8), p<0.001]. Post-simulations assessments also showed significantly increased confidence in assessing patients for tPA and embolectomy and working in a multidisciplinary environment. Overall, the simulation training increased the odds of residents being more comfortable with a Code Stroke (OR 8.2, 95% CI 5.8 – 11.6, p<0.001). | Good/#1462/ Code stroke simulation training benefits junior neurology residents. |
| Margiotta, et al. (2018) | Interventional study | Simulation | 1 | Neurological emergencies, Stroke | Neurology residents | No comparison group | Abstract | *Stroke* | There was then an immediate feedback session to review particular areas for improvement. The residents completed pre- and post- simulation tests to assess stroke knowledge and to determine confidence in responding to stroke alerts. | Prior to the stroke lecture and simulation, 44% of residents reported confidence responding to a stroke alert. After the simulation, 78% of residents felt confident. Only 44% of residents felt confident performing an NIHSS prior to the simulation versus 100% after the simulation. The number of residents who felt confident in their decision-making ability to give tPA increased from 22% to 56% after the simulation. | Good/#1138/ Improving resident confidence and efficiency during stroke alerts through simulation training. |
| Khanal, et al. (2015) | Interventional study | Simulation | 1 | Neurological emergencies, Stroke | 21 Neurology residents | No comparison group | Abstract | *Stroke* | Following the scenario the learner met one on one with staff for a debriefing session. Learner confidence in the management of acute stroke was assessed before and after the simulation experience using a 5 point Likert scale with 1=novice, 3=competent and 5=expert. Following the simulation, learners were asked to evaluate the experience (poor, needs improvement, good or outstanding). | Learner confidence improved from mean 2.81(SD-0.88) to 3.36(SD-0.73), p=0.03. Evaluations were favorable with all residents reporting a ‘good’ or ‘outstanding’ experience. | Good/#280/ Simulation based acute stroke training for neurology residents. |
| Lima, et al. (2019) | Interventional Study | Simulation | 1 | Neurological emergencies, Stroke | Neurology residents, 2 PGY-2, 1 stroke fellow | No comparison group | Abstract | *Stroke* | Each group was allotted 15 minutes to assess the patient, interpret results and advice management followed by a10 minute focused debriefing and feedback session. Objective improvements were assessed using paired T-test analysis of pre and post testing. | Pre vs. post simulation self-assessment survey of: I. Knowledge, understanding and management of acute stroke (2.83 +/- 0.82 vs. 3.63 +/- 0.6, p < 0.0001); II. Use of IV-tPA (3.13 +/- 0.85 vs. 4.17 +/- 0.70, p < 0.0001); III. Mechanical thrombectomy (3.00 +/- 0.83 vs. 4.13 +/- 0.74, p < 0.0001); IV. Blood pressure management (3.21 +/- 0.83 vs. 4.12 +/- 0.76, p < 0.0001); V. Team member responsibilities (2.73 +/- 0.98 vs. 4.08 +/- 0.83, p < 0.0001) and VI .Asking for help (3.71 +/- 1.04 vs. 4.58 +/- 0.58, p = 0.0003) improved. The role of neurology in stroke management from the ED perspective remained unchanged (3.75 +/- 0.99 vs. 4.13 +/- 0.74, p = 0.1191), however all quiz results improved (7.33 +/- 1.83 vs. 8.58 +/- 1.35, p = 0.0048). | Good/#1553/Improving acute stroke management through multidisciplinary case simulation. |
| Arista, et al. (2020) | Interventional Study | Simulation | 1 | Neurological emergencies, Status epilepticus | Medical Students | No comparison group | Abstract | *Neurology* | Pre and post-simulation surveys assessed attitude about status epilepticus management and feedback after the simulation. | 73 students participated in the simulation. After the activity, there was a statistically significant difference in the proportion of students that felt very confident (6 and 7 on a Likert scale) in creating a differential, diagnostic algorithm and managing a status epilepticus emergency. Closed loop communication and teamwork were mentioned more frequently than medication management as the most important learning points from the simulation. | Good/#2086/ Non-technical factors affecting student's status epilepticus simulation experience in a neurology clerkship. |
| Osgood, et al. (2019) | Interventional study | Simulation | 1 | Clinical Neurology, patient-care | 14 neurology residents | No comparison group | Abstract | *Neurocritical care* | A faculty facilitator observed each interaction, allowing residents to self-assess, obtain feedback from the actors and peers and then practice specific components of the conversation. Residents filled out a survey both prior to and following the simulation and the faculty filled out an evaluation for each of the residents. | 14 residents completed the training, 12 filled out a pre-survey. The majority (8/12) felt that the residency did not adequately prepare them to have GOC discussions though more than 50% of residents reported feeling comfortable and confident performing these discussions. The observing faculty found 10/14 residents require direct supervision and are not ready to have these conversations independently. All residents reported the training was a helpful, rewarding experience and improved their overall abilities to discuss GOC, address prognosis, and explore end-of-life issues. | Good/#1518/ Serious illness communication simulation for neurology residents-a pilot study |
| Guntur, et al. (2013) | Interventional study | Simulation | 1 | Clinical Neurology, patient care | 12 neurology trainees | No comparison group | Abstract | *Neurology* | The sessions were videorecorded and immediate feedback was provided to the participants by both the patient and a supervising physician who was monitoring the session. The participants were given the opportunity to review their recorded sessions either independently or with a Palliative Care physician. The residents and fellows' feedback was collected through a computerized survey at the end of the simulation session. | All twelve residents and fellows found the simulation to be educationally valuable. High marks were given to both the initial debriefing and the independent review of the simulated encounter. | Good/#1257/ A live patient simulation model for neurology residents and fellows to effectively communicate bad news. |
| Westwood, et al. (2012) | Interventional Study | Simulation | 1 | Clinical Neurology, Lumbar puncture | Medical students | No comparison group | Abstract | *Neurology* | Using six questions on a Likert scale ranging from 1-5 (5 being "expert, 1 being "unconfident", score total 30) medical students were surveyed before and after their use of a lumbar puncture simulator. | A total of 17 students were surveyed (11 MSIII and 6 MS IV). All students recorded an increase in confidence after use of the simulator. Typically fourth year students were more confident at baseline than third year students (13/30; 11/30) with greatly improved scores in comfort levels after use of the simulator (21/30, 22/30). Additional comments were all positive and students felt "more prepared for the wards" | Good/#147/ Lumbar puncture simulation training improves medical student knowledge and confidence. |
| Pirmohamed, et al. (2014) | Interventional study | Simulation | 1 | Clinical Neurology, headache | PGY2-5 Neurology residents | No comparison group | Abstract | *Headache* | Participant feedback through computerized survey. Debriefing with supervising physician. | All participants felt that this educational curriculum was clinically relevant. 92.3% found to be useful and found the initial curriculum on headache management and improving challenging patient encounters as well. | Poor/#926/ A live patient simulation model to effectively manage difficult headache patients. |
| Lewis, et al. (2017) | Interventional study | Simulation | 1 | Clinical Neurology, Brain death | 145 medical students | No comparison group | Abstract | *Neurocritical care* | Pre/posttest | Students correctly answered a median of 53% of questions (IQR 47-58%) on the pretest and 86% of questions (IQR 78-89%) on the posttest (p<0.001). Comfort with both performing a brain death evaluation and talking to a family about brain death improved significantly after this initiative (18% of students were comfortable performing a brain death evaluation before the initiative and 86% were comfortable doing so after the initiative, p<0.001; 18% were comfortable talking to a family abo | Good/#715/ Implementation of an educational initiative to improve medical student awareness about brain death |
| Legault, et al. (2018) | Interventional Study | Simulation | 1 | Neurological emergencies, Stroke | 22 neurology residents | No comparison group | Abstract | *Stroke* | Achievement of learning goals was measured with a pre- and post- multiple-choice quiz. Residents submitted anonymous written feedback that the authors analyzed with thematic coding. | Quiz grades improved from 67.5% to 78.3% after the simulation. Common feedback themes reference comfort with code logistics, imaging order entry, team member roles, benefit of realistic scenarios, and desire for more scenarios. The residents perceived simulation would relieve the stress of stroke call. The use of simulation was overall highly valued. | Good/#1139/ Stroke code simulation improves resident preparedness for call. |
| Gangadhara, et al. (2016) | Interventional study | Simulation | 1 | Neurological emergencies, Stroke | Neurology residents, medical students | No comparison group | Abstract | *Stroke* | Included 3 lectures on acute stroke care by USF faculty and 10 simulated scenarios of “Stroke Alerts” using standardized actors and electronic patient simulators. After each scenario, debriefing reviewed participants’ performance in Declarative and Procedural (Skill Set) Knowledge and Confidence. Results were analyzed using Likert scale on data collected prior to, and after, the course. | A repeated measures ANOVA demonstrated that, compared to pre-testing, post-testing data for Declarative and Procedural (Skill Set) Knowledge (F=14.05, p=.002) and Confidence (F=33.37, p<.001) of Acute Stroke management improved significantly for both residents and medical students alike. | Good/#630/ Virtual stroke patient simulation training for residents and medical students improves knowledge, skill sets and confidence in acute stroke care |
| O’Shaughnessy, et al. (2017) | Interventional study | Simulation | 1 | Clinical Neurology – Brain death | 722 residents | No comparison group | Abstract | *Transplantation* | In collaboration with the Trauma Director at a large urban trauma/transplant center created a simulated training program to equip residents with the knowledge, skills, and confidence required to have these difficult conversations about brain death. The training included a didactic session with a focus on the optimal donation process and simulated role-play scenarios where residents could practice their skills. The OPO served as faculty and coached the residents; providing immediate feedback based on a 12-point check list. | Pre training data showed that only 25% of residents were comfortable discussing brain death; this improved to 88% post training. When asked if it should be standard protocol to refer a neurologically injured patient to the OPO prior to brain death testing, 59% initially agreed; following the training, this improved to 93%. | Good/#1045/ Simulated explanation of brain death training improves resident communication competencies, leading to optimal family donation conversation by OPO staff |
| Barratt, et al. (2017) | Interventional study | Simulation | 1 | Clinical Neurology | 18 neurology residents, 25 3rd year medical students | No comparison group | Abstract | *Neurology* | Eighteen neurology residents (from 2 different institutions) and 25 third-year medical students (from a single institution) participated in a published coma simulation. Trainees were surveyed. | 100% of medical students responded the coma simulation allowed trainees to demonstrate the following: EPA 1--Gather a history & perform a physical examination; EPA 6-- Provide an oral presentation of a clinical encounter; EPA 9--Collaborate as a member of an interprofessional team; and EPA 11--Obtain informed consent for tests and/or procedures. 100% of neurology residents responded that the coma simulations allowed them to demonstrate the following: efficiently performing a relevant neurological exam and accurately incorporating all additional appropriate maneuvers; diagnosing brain death; analyzing and managing ethical issues in complex clinical situations; using easy-to-understand language in all phases of communication; leading team-based patient care activities; and effectively leading family meetings. 94% of neurology residents responded that the coma simulation allowed them to demonstrate the following: managing conflict in complex situations; mentoring others in the compassionate practice of medicine, even in the context of disagreement with patient beliefs; and mentoring others in sensitivity and responsiveness to diverse and vulnerable populations. 89% of residents responded that the coma simulation allowed them to demonstrate incorporating the patient’s sociocultural needs and beliefs into patient care. Narrative feedback from trainees was overwhelmingly positive. | Good/#990/ Published Coma Simulation had Face Validity in allowing trainees to demonstrate Neurology Residency Milestones and AAMC Entrustable Professional Activities. |
| Tariq, et al. (2014) | Interventional study | Simulation | 1 | Clinical Neurology | 13 neurology residents | No comparison group | Abstract | *Neurology* | Pre and post simulation MCQs(based on Likert scale) were filled out by all residents. Debriefing sessions were lead by subspecialty attending physicians and senior residents for formative feedback to the residents following each scenario. | Out of 13 participating neurology residents,84% to 100% of them agreed that these simulation sessions met the stated clinical objectives. All residents (100%) agreed that overall quality and utility of debriefing sessions were good. Approximately 84% agreed that the simulation experience was more useful than reading a chapter or attending a lecture about the designated topics. After completing the sessions, all surveyed residents agreed that they will be able to better manage future similar clinical situations as compared to before the training. For the stroke code simulation session, there was a remarkable improvement between pre and post simulation scores i.e. (increased from 33% to 87%) with regards to agreement in” feeling comfortable running a stroke code as a first responder from neurology service.” | Good/#917/ Simulation boot camp for neurology residents: A unique experience from a training perspective. |
| Osgood, et al. (2019) | Interventional study, observational, pilot study | Simulation | 1 | Clinical Neurology | Neurology residents | No comparison group | Abstract | *Neurology* | A faculty facilitator observed each interaction and called time-outs, allowing residents to self-assess and obtain feedback from actors and peer residents. Following the simulation, residents debriefed as a group to identify take-home points to guide their clinical practice, as well as reflect on their own emotions, self-care and sense of purpose in medicine. | Eight out of 10 residents completed pre-surveys and all residents submitted post-session evaluations. Faculty facilitators and actors found residents had difficulty dealing with strong emotions, displaying empathy, and maintaining silence. All residents reported the simulation was a helpful, rewarding experience and improved their abilities to discuss GOC, address prognosis, and explore end-of-life issues with patients. | Good/#1599/ Enhancing skills in serious illness communication in neurology residents using simulation-a pilot study. |
| Sabharwal, et al. (2015) | Interventional study, opinion/overview  | Simulation | 1 | Clinical Neurology | 29 neurology residents | No comparison group | Abstract | *Neurology* | Residents were given evaluation forms to test objective knowledge as well as self-assessment of knowledge, competency and comfort level on a 10-point scale before and after each session. | There was a significant gain in self-assessment of knowledge (means on 10-point scale; stroke pre-4.4, post-7.7, p-value<0.001; critical care pre-3.97, post-6.35, p-value<0.001; neuro-ophthalmology pre-2.2, post-6.23, p-value 0.04), competency (stroke pre-2.8, post-6.4, p-value<0.001; critical care pre-3.4, post-5.9, p-value<0.001). Residents also reported an improvement in their comfort level with various skills (stroke pre-3.4, post-7.4, p-value 0.006; critical care pre-3.2, post-6.2, pvalue 0.02; line-placement pre-4.5, post-7.1, p-value<0.001; neuro-ophthalmology pre-2.3, post6.3, p-value<0.001). | Good/#312/A comprehensive simulation curriculum for neurology residents-preparing for future challenges in neurology |
| Morris, et al. (2019) | Interventional study, pilot study | Simulation | 1 | Neurological emergencies | 24 participants (residents, fellows, neurocritical care attendings) | No comparison group | Abstract | *Neurology* | Performance is evaluated by 2 raters and inter-rater reliability will be established via the kappa statistic. Participants measure content validity by Likert scales. | 24 participants have taken part in 76 simulation scenarios. The mean satisfaction score among for the simulation scenarios was 6.75/7. The mean score for realism of the cases was 6.25/7. All participants agreed or strongly agreed that the simulations increased their experience, proficiency, and confidence in treating neurological emergencies. All participants agreed or strongly agreed that they would benefit from more simulation in their training and that they prefer simulation to didactic teaching for learning about neurological emergencies. | Good/#1583/ Development and validation of simulation scenarios for performance assessment in neurological emergencies. |
| Zairinal, et al. (2020) | Interventional Study, single center, cross-sectional | Simulation | 1 | Clinical Neurology | 1st year medical students | No comparison group | Abstract | *Neurology* | After completing the simulation, they were asked to fulfill it without any pressure from other people. Statistical analysis was conducted to find the proportion and central tendency values of the variables. | Of 178 students enrolled, 32 students responded (18.0%). The mean GPA was 3.54±0.142. Half of them had previous experience with the simulation. Twenty-two (38.6%) students reported traumatic brain injury (TBI) as their simulation cases, followed by intracerebral hemorrhage (26.3%), subarachnoid hemorrhage (24.6%), and TB meningitis (10.5%). In their real-life situation, TBI also the most encountered case in the emergency room as it was experienced by 29 students (24.2%). Following that, there was ischemic stroke (22.5%), intracerebral hemorrhage (20.8%), intracranial infection (17.5%), and metabolic encephalopathy (8.3%). In terms of suggestion, several things that need to address were to have more frequency and duration of practice sessions (44.7%), increase cases diversity (15.7%), and improvement of protocols and facilities (7.8%). All students (100%) agreed that this simulation activity should be held regularly. | Good/#2072/ Introducing high-fidelity acute neurology simulation for medical students. |
| Uppal, et al. (2013) | Interventional, comparison study | Simulation | 1 | Neurological emergencies, Stroke | 9 neurology residents | Compared to previous historic controls | Abstract | *Neurology* | Historic controls consisting of PGY2 residents without simulation were used. Pre & post simulation survey, SP comments and debriefing was done for each scenario. | Residents reported 100 % satisfaction with quality of demonstrations and hands-on learning experience. The accuracy and timing of decision making-IV thrombolytic, No Thrombolytic or catheter based reperfusion was significantly better to historic control and from 1 to the 4 case scenario. Significant improvement was also seen in patient interaction, utilizing NIHSS and ABCD2 score in decision making, indications and contraindications to thrombolytic, utilization of resources including CT & CTA, CT perfusion and MRI of brain, door to needle time and consulting Neurointerventionalist. | Good/#1249/ Stroke simulation enhances resident's confidence in acute stroke/TIA management. |
| Khan, et al. (2018) | Interventional, comparison study | Simulation | 1 | Neurological emergencies, Stroke | APPs, neurology residents | Neurology residents vs APPs | Abstract | *Neurology* | APPs and residents completed a survey before and after the simulation. | Confidence in leading a stroke code increased from 2.4 to 4.2 (p < 0.05) among APPs. APPs reported improved comfort level in rapidly assessing a stroke patient for thrombolytics (3.1–4.2; p < 0.05), making the decision to give thrombolytics (2.8 vs 4.2; p < 0.05), and assessing a patient for embolectomy (2.4–4.0; p < 0.05). There was no difference in the improvement observed in all the survey questions as compared to neurology residents. | Good/#1111/ Stroke code simulation benefits advanced practice providers similar to neurology residents. |
| Wendell, et al. (2016) | Interventional, comparison study | Simulation | 1 | Neurological emergencies, Stroke | 23 neurology residents | No comparison group | Abstract | *Neurology* | Residents completed a survey before and after the simulation. | Based on a 5-point Likert scale (1 – least true and 5 – most true), residents reported significantly increased confidence in leading a Code Stroke [mean 2.9 (SD ±0.8) vs. 3.9 (±0.5), p<0.001] and increased preparedness for their next Code Stroke [3.0 (±0.6) vs. 4.1 (±0.7), p<0.001]. Residents were least confident managing coagulopathy in patients with ICH; the simulation also significantly increased their confidence in managing these patients [2.4 (±1.1) vs. 3.5 (±0.8), p<0.001]. Post-simulations assessments also showed significantly increased confidence in assessing patients for tPA and embolectomy and working in a multidisciplinary environment. Overall, the simulation training increased the odds of residents being more comfortable with a Code Stroke (OR 8.2, 95% CI 5.8 – 11.6, p<0.001). | Good/#633/ Code stroke simulation training benefits junior neurology residents. |
| Ali, et al. (2018) | Interventional, investigational, pilot study | Simulation | 1 | Clinical Neurology, Lumbar puncture | Neurology trainees | No comparison group | Abstract | *Academic Radiology* | Preliminary data from users who participated in the simulation were obtained in a postsimulation survey. | All users found the simulation to be a realistic replication of the anatomy and procedure and would recommend to a colleague. On a scale of 1–5 (lowest to highest) rating the virtual simulator training overall, the mean score was 4.3 (range 3–5). | Good/#1167/ Virtual Simulation in Enhancing Procedural Training for Fluoroscopy-guided Lumbar Puncture: A Pilot Study. |
| Zhang, et al. (2017) | Interventional, observation study | Simulation | 1 | Clinical Neurology, Brain death | 722 residents | Surgical vs non-surgical residents | Abstract | *Journal of the American College of Surgeons* | Resident knowledge and comfort were evaluated in pre- and post-didactic assessments. | Sixty-nine percent of trainees had taken care of at least one patient with traumatic brain injury leading to brain death prior to the didactic program. However, 42 percent reported never receiving instruction on how to explain brain death. Residents’ knowledge of the definition of brain death improved after the educational session. More trainees indicated in the post-assessment that conversations about donation should occur after pronouncement and after the family has achieved understanding of brain death as death (94% vs 55%, p<0.05). Participants also reported feeling more comfortable and confident discussing brain death after the didactic. On subset analysis, the improvement in responses was not significantly different between surgical and non-surgical residents. | Good/#1062/ Formal didactic training improves resident understanding and communication of brain death. |
| Uppal, et al. (2013) | Interventional, observational study | Simulation | 1 | Neurological emergencies | 137 medical students | No comparison group | Abstract | *Epilepsy Currents* | Phase 1: Self reading of an Article on SE. Phase 2: Students worked in groups of 3-4 for the management a 35 yr old continuously seizing patient for 3 hrs. Phase 3: Post-Simulation questionnaire and Debriefing by clerkship director along with a survey for feedback | The students performed remarkably well with scoring above 90% in management of SE. About 95% of the students agreed that the simulation will help manage real life patients better; also this way of learning appeared better than the regular didactic session and they will remember the management protocol better. | Good/#1252/ The use of hi-fidelity mannequin for status epilepticus simulation to enhance medical student's performance. |
| Patel, et al (2019) | Interventional, observational study | Simulation | 1 | Clinical Neurology, Brain death | 17 neurology residents | No comparison group | Abstract | *Neurology* | Neurology residents collaborated in pairs to review clinical data, establish the prerequisites and perform the brain death exam and apnea test. Faculty facilitators completed a checklist for all the components of the exam and gave immediate feedback. Afterwards, learners completed a survey about the workshop | Facilitators provided formative feedback to all learners in real-time. After completing the workshop, learners’ self-assessed ability to recall prerequisites to brain death increased by 83% and comfort levels with performing brain death exam, performing apnea test, and diagnosing a patient with brain death increased significantly by 85%, 117%, and 75%, respectively. | Good/#1596/ Brain death determination skills workshop for neurology residents. |
| Wang, et al. (2013) | Investigational, interventional study | Simulation | 1 | Clinical Neurology | N/A | No comparison group | Abstract | *Proc IEEE IUnt Conf Robotics Autom* | Simulate various symptoms occurring during the examination of elbow force, biceps tendon reflex, involuntary action, and also make a physiological neurological model to simulate the pathology of the nervous system. | Taking advantage of this robot, the trainee can get a systematic training on both the skills and knowledge. Finally, we take a set of experiments to verify our proposed mechanism and system. | Good/#4940/ Development of a human-like neurologic model to simulate the influences of diseases for neurologic examination training. |
| Dwoertzky, et al. (2011) | Mixed, methods, investigational study | Simulation | 1 | Clinical Neurology, EMU | Nurses, physicians | No comparison group | Abstract | *Epilepsy Currents* | After receiving an introduction emphasizing teamwork, leadership, communication, and evaluation of change in patient condition in the EMU, subjects were introduced to the medical simulator. Employing the procedural checklist and through interactive video-debriefing, trained facilitators identified strengths and weaknesses of individual and team performance and emphasized essential objectives. | A practical simulated curriculum is feasible and valid to train seizure safety in the EMU and may have broader applications for safety training.  | Good/#60/ Medical simulation of sentinel events: VAlidation and implementation of a team training curriculum for patient safety in the epilepsy monitoring unit (EMU). |
| Bashir, et al. (2017) | Quality improvement study | Simulation | 1 | Neurological emergencies | PGY-2 residents | No comparison group | Abstract | *Neurology* | Primary outcome was self-reported readiness before and after the simulation course. Secondary outcome was their assessment on the course. | Four PGY-2 neurology residents participated in the project. There was an improvement in self-reported readiness in all categories of each scenario after the simulation course, although it did not reach statistical significance. Overall feedback regarding the value and desire to continue the simulation course and its appropriateness and achievement of objectives were all positive. | Good/#977/ Utility of an Emergency Neurologic Life Support- based simulation course for First Year Neurology resident independent call readiness: A Quality Improvement Project. |
| Wu, et al. (2019) | Single group, interventional study | Simulation | 1 | Neurological emergencies | 22 PGY2-4 Neurology residents | No comparison group | Abstract | *Neurocritical Care* | assesses for self-perceived comfort/confidence levels, future interest, and checklist item completion. | 62.5% of all trainees reported no more than somewhat comfortable in treating neurological emergencies despite having received some type of neurological emergency training through didactic lectures. 90.9% felt more comfortable in treating specific simulation case in which they participated. All were interested in additional sessions. | Good/#1516/ The implementation and assessment of a comprehensive simulation-based curriculum in treating acute neurological emergencies at UC San Diego: Preliminary results and findings. |
| Harmon, et al. (2017) | Interventional study | Smart phone, App | 1 | Neuroanatomy | 1st year medical students | 195 medical students, no control group | Abstract | *Clinical Anatomy* | Following the curricular block's final exam, a 26‐question survey based on the technology acceptance model (TAM) was distributed to measure students’ acceptance of the new technology. The determinate relationship between students’ perceived ease of use, perceived usefulness, perceived enjoyment, personal innovativeness and behavioral intention towards using the 4natomy mobile app were analyzed through structural equation modeling. | Of the 195 first year medical students, 106 students downloaded and used the app at least one time. Of these 106, 80 students (75.5%) completed the survey. Survey responses indicated that student perception of the ease of app use was a significant determinant on perceived enjoyment of the app (p< .001), perceived usefulness of the app (p< .001) and student intention to use the mobile app in the future (p= .039). Student self‐perception of being personally innovative had a significant effect on perceived usefulness of the app (p= .005) and intention to adopt the mobile app in the future (p= .03). Student perceived usefulness of the mobile app was the strongest determinant of intention to adopt the mobile app in the future (p< .001). | Good/#1038/ Development of a novel integrated anatomical sciences mobile app for medical students |
| Mtui, et al. (2017) | Interventional study | Smart phone, App | 1 | Neuroanatomy | Medical students | No comparison group | Abstract | *Clinical Anatomy* | The app utilizes mouse-over and overlay technology, allowing users to easily highlight and select different areas of the brain and spinal cord and their related structures; it allows students to access the self-assessment tools onto the image overlays so that students can test their knowledge as they progress. C | A recent student evaluation reflects students rating the overall quality and usefulness of the FNAR as “excellent” (3.85 on a 4-point scale). | Poor/1037/ Functional neuroanatomy resource innovation for iPads |
| Dunn, et al. (2017) | Interventional study | Smart phone, App | 1 | Clinical Neurology | 38 medical students | No comparison group | Abstract | *Clinical &Experimental Opthalmology* | Students completed examinations on simulators and patients, with a crossover between smartphone and direct fundoscopy. Following they were surveyed on: preferred technique for fundoscopy; confidence; and ease of viewing the fundus. | Students responded favorably to smartphone‐assisted fundoscopy (SF) over direct ophthalmoscopy (DO). 75%preferred SF over DO (p = 0.007), Confidence levels viewing fundus on a 1‐5 Likert scale (1 being least confident) was 3.500 (95% CI[3.17‐3.83]) for SF vs 3.031 (95% CI [2.69‐3.37]) for DO (p = 0.037). Ease of viewing fundus was 3.469 (95% CI [2.14‐2.80]) for sSF and 2.844 (95%CI [2.49‐3.20]) for DO (p =0.037). | Good/#2201/ Efocus phase 2: a randomised crossover trial of smartphone & direct fundoscopy for medical students. |
| Hennessy, et al. (2015) | Interventional, observational study | Social media | 1 | Neuroanatomy | 2nd year medical students | No comparison group | Abstract | *FASEB Journal* | The nlm2soton hashtag was created and was displayed (via a widget) on the University's Virtual Learning Environment (Blackboard) for a cohort of 203 BM5 Year 2 medical students studying neuroanatomy. Student usage was tracked to measure levels of engagement throughout the course. | 62% of the cohort viewed the widget with on average 30 hits per day. A 16% increase in the widget's daily hits coincided with the January revision period. 33% of the cohort tweeted or favoured tweets which were themed as follows: Shared learning (29%), Morale boosts (28%), Questions (23%), Worries (16%) and Information (4%). | Good/#302/ Using social media as an educational tool: The potential role of twitter in enhancing the student learning experience in Neuro/Anatomy. |
| Wong, et al. (2018) | Interventional, comparison study | Social media, eLearning | 1 | Clinical Neurology | 40 medical providers | No comparison group | Abstract | *Neurology* | Participants were encouraged to discuss neurology topics, and were allowed to ask instructors questions during and after course completion. Qualitative assessment using surveys determined participant satisfaction with the FB. | 30 participants completed post-course surveys. 100% reported having a Facebook account, and 91% accessed Facebook daily. 100% reported they found the FB useful for this course. Participants listed the most useful aspect of the FB as “encouraging discussion with other students” (53%) and “access to education materials” (43.3%). 100% also reported they would like to see social media used in medical education in their future. | Good/#1452/ Using social media to enhance neurology education and engagement during short-term global health initiatives. |
| Stephens, et al. (2019) | Interventional study | Social media, Instagram | 1 | Neuroanatomy | Medical students | No comparison group | Abstract | *Journal of Anatomy* | We posted on average two images (labelled drawings with annotated notes) per week which aligned to the taught study material. Additionally, we uploaded short screencast videos via YouTube and answered questions via a dedicated hashtag on Twitter. Subsequently, students completed a 5-point Likert style questionnaire. | On average students accessed the Instagram account one to three times per week. The preferred social media platform overall was YouTube (80.4%), with Instagram receiving only 13.6% of the vote. Both Twitter and Facebook trailed with 3.7% and 1.4%, respectively. Furthermore, students preferred YouTube (4.8/5) over Instagram (4.5/5) (P < 0.002). The preferred type of Instagram post was images with descriptive text (34.6%) compared with 60-s videos (25.2%) or summary tables (24.8%). Despite this, the majority believed Instagram was a very good way to share learning resources (4.1/5). | Good/#1569/ Instagram and anatomy: Can it compete with the big three social media networks in anatomy education? |
| Brich, et al. (2017) | Cross over, interventional study | TBL (team based learning) | 1 | Clinical Neurology | 122 3rd and 4th year medical students | Team based vs. interactive seminars | Abstract | *Neurology* | Knowledge was assessed with a multiple-choice question examination (MCQE), CR skills with a key feature problem examination (KFPE). Questionnaires were used for further methodologic evaluation. | No group differences were found in the MCQE results. sTBL instruction of the topic “acute altered mental status” was associated with a significantly better student performance in the KFPE (p = 0.008), with no differences in the other 3 topics covered. Although both teaching methods were highly rated by the students, a clear majority voted for sTBL as their preferred future teaching method. | Good/#1051/ Teaching neurology to medical students with a simplified version of team-based learning. |
| Dayas, et al. (2020) | Interventional study | VR | 1 | Neuroanatomy | 177 medical, OT, biomedical science, and medical radiation science students | No comparison group | Abstract | *Clinical Anatomy* | An augmented reality (AR) application designed to over-lay three-dimensional models of deep brain structures on two-dimensional brain scans was developed as a collaborative project utilizing specialist technical expertise. | Student volunteers (n=177: Medicine, Occupational Therapy, Biomedical Science and Medical Radiation Science) evaluated the Brain Scan AR application (Likert scale: strongly disagree, disagree, neutral, agree, strongly agree). (1) Effectiveness in illustrating 3D brain architecture (98% = strongly agree/agree) (2) Ease of use (95.5% = strongly agree/agree) (3) More effective than cadaveric brain sections, models, textbook images (87.6% = strongly agree/ agree) | Good/#2100/ The brian scan augmented reality (AR) application for learning three dimensional (3D) relationships of deep brain structures. |
| Holton-Burke, et al. (2019) | Interventional study | VR | 1 | Clinical Neurology | 3rd year medical students | No comparison group | Abstract | *Neurology* | Each student experienced both the VR experience and the instructional video. This was followed by a debriefing session. | Learners reported a significant increase in competency of treating epilepsy. There was also a reported increase in empathy and developing methods to communicate with patients with seizures. Learners came from a diverse range of experience in using VR devices and very few had used VR for educational experiences | Good/#1600/ The addition of virtual reality into the neurology curriculum. |
| Lelos, et al. (2014) | Interventional study | VR, eLearning, holography | 1 | Clinical Neurology | 45 medical students | No comparison group | Abstract | *Journal of Neurology, Neurosurgery and Psychiatry* | Primary outcomes consisted of subjective metrics on education impact by (i) answering a 10-point questionnaire on a 7-point Likert scale (ii) undergoing a 5-minute semi-structured interview using thematic analysis. | 45 (90%) participants completed the 10-point perception questionnaire using a 7-point Likert scale. 1 being strongly disagree and 7 being strongly agree. Out of 10 questions, 6 questions had a median of 5, 3 questions had a median of 4 and only one question had a median of 3. | Good/#946/ Augmented reality dynamic holography for neurology |
| Adegboye, et al. (2017) | Interventional study | VR, hololens, PBL | 1 | Clinical Neurology | Medical students | Control vs intervention group | Abstract | *Journal of General Internal Medicine* | The students took a quiz to assess their knowledge and a survey to assess their cognitive load and learner satisfaction. | 30% of the students in the HoloLens group felt that it was easy to learn the concepts compared to 11% in the control group. Of the students in the HoloLens group, 80% believed that the addition of HoloLens would enhance how neuroanatomy was currently taught, assuming that the appropriate HoloLens content was available. Furthermore, 67% agreed that they would want to use HoloLens to learn other medical content. | Good/#997/ The use of hololens to enhance the medical school learning experience. |
| Campbell et al. (2017) | Interventional Study, pilot study | 3-D modeling/printing | 0 | Clinical Neurology, Stroke | N/A | No comparision group | Abstract | *Stroke* | This physical simulator was built for neurosurgical residents and fellows to practice mechanical thrombectomy. | Using 3D printing technology and polymer hydrogels, a low-cost, high fidelity stroke model was achieved. Despite its simplified anatomy, the model permitted realistic wire and catheter navigation through the different segments of the internal carotid and middle cerebral arteries. The ACOM sheath provided a convenient method to reliably place an embolism and created a life-like proximal M1 occlusion. | Good/746/Cerebral mechanical thrombectomy simulator using hydrogel polymers and 3D printing technology. |
| Border, et al. (2020) | Comparative study, interventional study | eLearning (YouTube), peer teaching | 0 | Neuroanatomy | N/A | Intervention group vs traditional education | Abstract | *Journal of Anatomy* | N/A | N/A | Poor/#1885/ Inclusivity in anatomy education: Working with students as partners in the development of e learning |
| Dawe, et al. (2019) | Intervention study | eLearning, video based learning | 0 | Neurological emergencies, Stroke | Physicians completing neurology rotation | Intervention group vs 1 year prior physicians | Abstract | *International Journal of Stroke* | Objective knowledge and subjective comfort performing the ASP assessed through a questionnaire. ASP efficiency is defined by door-to-CT (DTCT) and door-to-needle (DTN) times after video implementation. | Data pending | Poor/#1811/ Utilization of video-based education to enhance resident physician comfort and performance in acute stroke assessment. |
| Long (2017) | Feasibility, developmental study | Flipped classroom | 0 | Clinical Neurology, Coma | N/A | No comparison group | Abstract | *Neurocritical care* | Targeted needs assessment solicited expert opinion on educational needs within the fields of Neurocritical Care, Neurology, Emergency Medicine, and Critical Care. Goals and objectives for each unit and for the overall project were developed. Educational strategies for individual units were tailored to the goals of the unit. Initial implementation is being piloted with Neurology residents at Northwestern McGaw Medical Center. | Six units were developed and are being delivered as participatory lectures, flipped-classroom discussions, reference materials, and bedside skill training: (1) Coma Examination and Determination of Brain Death, (2) Structural Causes of Coma, (3) a unit that delves deeper into Specific Structural Causes of Coma, (4) Metaboli | Poor/#716/Development of a curriculum to teach coma |
| Marais, et al. (2020) | Interventional study | Gamification | 0 | Neuroanatomy | Medical students | No comparison group | Abstract | *Journal of Anatomy* | Multidisciplinary team of content experts, game and software designers and the artists to develop a mobile compatible neuroanatomy game that is easy to use and yields learning results for students.  | A narrative arc was developed for the game and chapters with three levels from beginner to expert were created based on the learning objectives of the neuroanatomy lab sessions. Principles of design thinking and iterative software were applied in the creation of this game so that the product would meet both the learning objectives of the course and the objective to keep the game fun and competitive.  | Weak/#1883/ Game the Brain! the iterative, multidisciplinary development of a mobile neuroanatomy game that is both fun and educational. |
| Okudera, et al. (2013) | Interventional study | Simulation | 0 | Neurological emergencies, Stroke | N/A | No comparison group | Abstract | *Clinical Neurology* | N/A | N/A | Poor/#809/ Immediate stroke life support: Training for neuroresuscitation team in ER |
| Dangayach, et al. (2013) | Randomized, feasibility, interventional and comparative study | Simulation | 0 | Neurological emergencies | 20 neurology residents | Simulation based learning vs. Traditional didactic teaching | Abstract | *Neurocritical care* | Learning objectives will be assessed using crisis resource management (CRM) assessment tools including identification of key actions, time to key actions, Ottawa global rating score and Ottawa CRM checklist, and finally knowledge basedtests both pre- and post-intervention. Learner satisfaction through survey feedback and learner retention will be assessed on the same outcomes for both groups at 3 months. | It was feasible to simulate real life scenarios for common neurological emergencies present in a neuro ICU setting. | Good/#1316/ High-fidelity simulation versus traditional didactic techniques for teaching neurological emergencies to neurology residents: A randomized controlled study. |
| Marin, et al. (2015) | Interventional study | Simulation | 2 | Clinical Neurology, Brain death | 5 incoming neurology residents | No comparision group | Absract | *Neurocritical Care* | Pretest (10 questions), posttest, participation feedback | All participants reported improvement in level of comfort and knowledge after the exercise. Pre-test test showed an average score of 56% and post-test an average score of 88%, translating into a 32% of improvement with a p value < 0.05. | Good/#558/ Simulation-based learning in the brain death evaluation among incoming neurology residents |