Active learning in neuroscience: a manipulative to simulate visual field defects

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Prevalent in 20–57% of stroke patients, visual field defects have been shown to impact quality of life. Studies (8) have shown increased risk of falling, ambulatory difficulties, impaired reading ability, and feelings of panic in crowded or unfamiliar places in patients with visual field defects. Rehabilitation, independence, and mental health may also be impacted (8). As future physicians who may encounter patients with visual field defects in practice, it is important for medical students to learn the science and clinical presentation behind vision loss. Unfortunately, many medical students today rate their neurology knowledge lower than that of other medical fields, and believe that the method of teaching neurology in medical schools can be improved (9). There are several methods in education that may assist medical students in learning science: active learning (4), making learning fun (2), and teaching how to use knowledge rather than just teaching knowledge itself (5). Active, student-centered learning methods have been shown to be effective in settings of higher education (6). Medical students who underwent a team-based learning approach in neurology achieved higher mean posttest scores over classmates who participated in the passive learning approach (9). Teaching tools can be utilized in neurological curricula as well. At the undergraduate level, manipulative teaching tools have been shown to be effective in teaching neurophysiology concepts and improving student performance (5). One institution implemented a CD-ROM of 100 neurology patient interviews with medical students, who reported high approval ratings of the tool (1).

This tracking study follows first-year medical student learning through implementation of a visual field defects teaching tool incorporating elements of active learning, fun in learning, and application of knowledge to clinical situations. Students used masks with attachable cutouts to simulate visual field defects on themselves and their classmates. The simulation was paired with an interactive workshop and clinical application to reinforce concepts. We hypothesized that modeling defects using the mask will improve student knowledge and confidence of visual field pathophysiology and clinical presentation.

MATERIALS AND METHODS

Participating students. Thirteen first-year medical students from the Virginia Tech Carilion School of Medicine participated in the activity as the experimental group. The first-year students received lectures on optic anatomy and physiology and self-taught visual field defects through problem-based learning the week prior to the activity. Because of the small sample size, there was no control group. Virginia Tech Carilion School of Medicine Institutional Review Board applications were submitted and accepted.

Model construction. Cut eight 1.5 × 0.5 in. strips of hook velcro, and place the adhesive ends in a diamond shape around each eye hole on the mask, as shown in Fig. 1. Cut four 1.5 inch × 2 inch rectangles of loop velcro. Make one 0.25 × 0.125 in. incision into the center of the long side of two loop rectangles and the short side of two loop rectangles as shown (Fig. 1).

Model use. The final product is a wearable mask that students can use with attachable pieces to block specific regions of their visual fields, simulating the defect firsthand. The four velcro rectangles are used to simulate five types of visual field defects as shown (Fig. 2). Anopia (loss of entire visual field) was simulated by having students close one eye. Rectangles can be switched for left- vs. right-sided lesions of the same type. Students can adjust the fit of the mask using the straps and adjust rectangle placement depending on individual eye position. It is helpful to have a partner available for adjustment assistance. Rectangles should be placed snugly, especially in the nasal and temporal peripheries, where light can pass through if placed too loosely. The model can be used as a teaching and testing tool. Students can see what a specific defect looks like while learning about the lesion. Alternatively, students can be asked to create the defect on their masks when given a specific lesion or asked to name the lesion given a defect on their masks.

Data collection. Before the activity, students responded to six questions on the six visual field defects covered and also self-reported their confidence level in the subject. Confidence was rated on a scale from 1 to 5 representing poor, fair, average, good, and excellent grasp of the material. At the end of the activity, students responded to six different questions testing the same pretest concepts along with confidence measurement and subjective feedback on session effectiveness. Responses to the survey were anonymous and voluntary.

Presentation of activity. The entire session was 45 min in length. After the pretest, a brief review on optic pathway anatomy was given to ensure baseline understanding. Six visual fields were covered: anopia, bitemporal hemianopia, homonymous hemianopia, upper quadrantic hemianopia, lower quadrantic hemianopia, and homonymous hemianopia with macular sparing. Students were split into groups of three to four per mask and were shown how to simulate the defect on their masks. Self-generated and board review-derived clinical vignettes were presented as the students wore the mask. Students were asked to briefly act out certain vignettes (e.g., reaching for an object, tilting head to see). For each defect, students were asked to recite the name, point to the area, and name the lesion on themselves and their peers and differentiate between left and right while wearing or manipulating the mask. A review was held afterward, presenting six different patient cases with similar vignettes, as covered previously. Students were asked to produce the correct defect on the mask and name the respective lesion. The posttest was given at the end of the activity. Paired t-tests on test score performance and confidence level were performed to determine whether the activity was effective.
RESULTS

The percentage of correct answers was 49 ± 23% (means ± SD) before the activity, and 95 ± 8% after the activity (Fig. 3). 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 (Fig. 4). The mean posttest score percentage increase \( M = 0.46, SD = 0.21, n = 13, 95\% \text{ CI}, 0.34–0.59 \) was significantly greater than zero, \( t(12) = -8.1 \), two-tailed, \( P = 0.000003 \). The mean posttest confidence increase \( M = 1.0, SD = 0.71, n = 13, 95\% \text{ CI}, 0.57–1.4 \) was significantly greater than zero, \( t(12) = -5.1 \), two-tailed, \( P = 0.0003 \).

Test scores were widely distributed before the activity. After the activity, the test scores were equal to or higher than 83%, with 67% of students scoring 100%. Postactivity confidence measurements showed that no students had declined, three students had no change, and 10 students had improved. The majority of students rated themselves as 2 (fair) and 3 (average) confidence before the activity, whereas after the
activity the majority of students rated themselves as 4 (good) and 5 (excellent). There is an overall positive shift in most students toward increased confidence and performance after the activity.

DISCUSSION

Findings suggest that the visual field defects mask is an effective neurology manipulative in an active learning setting. Reception to the model as a learning tool was positive overall. It was interesting to see students approach the activity from multiple angles. Students manipulated the mask, simulated the defects on themselves and their peers, and even used their fingers to simulate visual field defects when the mask was off. Results showed statistically significant improvements in mean test scores and confidence levels after the activity.

Active learning has been shown to increase student performance in the sciences (3, 4). Student confidence in material has been shown to correlate with performance in mathematics (7). After the activity, students demonstrated improvement not only in self-confidence in knowing visual field defects but also in test scores on concepts. Students with both low and high confidence before the activity demonstrated improvements in test scores after the activity. There was no decline in confidence levels or test scores after the activity. These findings suggest that this activity may have the potential to both teach and reinforce concepts to students regardless of their initial level of confidence and understanding. Students liked using the manipulative with clinical correlates. They found it helpful to use the mask to apply what they learned in trying to determine the visual field defect from patient vignettes. This study suggests that active learning through manipulatives and group activity may be effective in teaching neurological concepts to medical students. Furthermore, student feedback and results suggest that this active learning tool may be a good alternative or complement to more traditional, lecture-oriented neurology curricula.

Limitations and possibilities. There were several limitations in this study, such as time constraints, that prevented students from further exploring the manipulative and its application. Another limitation is the lack of long-term followup to measure retention of knowledge. A structured session with instructions with a larger sample size is necessary to further test the efficacy of the model. A larger number of masks would be helpful so that each student has their own instead of sharing it with two to three other students. It would be useful to score performance on United States Medical Licensing Examination board style questions before and after the activity to determine whether the mask influenced application of concepts in standardized testing.

There are also many possible ways of using the manipulative still to be explored, such as having one student place the defect onto his/her peer wearing the mask and asking him/her to name the causative lesion. The small sample of volunteer students prevented us from having a true control group, in which a different group of first-year medical students would have the same presentation without the mask. After approval from curriculum directors, future tests will involve dividing the entire first-year class into the experimental group that uses the manipulative and the control group that receives a traditional lecture on the subject.

Conclusions. This manipulative tool has the potential to easily be incorporated into the ever-evolving curricula in medical schools across the nation. The mask is an inexpensive, fun, and easy to use and apply model that can possibly be used in a variety of classroom sizes and settings as well as a metacognitive tool for self-study. The model shows versatility in use for simulating, learning, teaching, and testing neuroscience and clinical neurology concepts. Most importantly, simulation of clinical pathology in an active learning setting using this model may be a useful tool to improve student confidence in learning and applying concepts of visual field defects. As such, we hope that this model may one day pave the way toward improving not only comprehension of neurological concepts in medical students but also retention and comfort in future practice.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

A.Y.-L.L. conception and design of research; A.Y.-L.L. and H.C. performed experiments; A.Y.-L.L. and H.C. analyzed data; A.Y.-L.L. and H.C. interpreted results of experiments; A.Y.-L.L. and H.C. prepared figures; A.Y.-L.L. and H.C. drafted manuscript; A.Y.-L.L. and H.C. edited and revised manuscript; A.Y.-L.L. and H.C. approved final version of manuscript.

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Fig. 4. Mean confidence levels on the pre- and posttests.