Teaching of neuroanatomy by means of self-instructional laboratory stations

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Summary

Neuroanatomical laboratory material was presented to first-year medical students in a series of six self-instructional stations. Each station was designed to emphasize one major objective and to be completed without reference to any other station. Upon completion of a station the students filled out a response questionnaire. Five weeks later, short examinations testing both station content and application of the neuroanatomical principles were administered to volunteers from the class.

Student response to this teaching format was highly favourable for all areas questioned. Results of the tests indicated a mastery of station material as defined by the objectives and an ability to use the material in applied problems. The laboratory station concept is economical of both student and instructor time and allows flexibility in the design of neuroanatomical laboratory experiences.

Key words: NEUROANATOMY/*educ; *EDUCATION, MEDICAL, UNDERGRADUATE; *TEACHING MATERIALS; LABORATORIES; TEACHING/methods; MICHIGAN

Introduction

Neural and Behavioral Sciences at the University of Michigan Medical School is a four-semester course involving neuroanatomy and several other disciplines. As this course evolved, less time was allotted for laboratory sessions in neuroanatomy chiefly because fewer instructors were available. In addition, to improve instructor efficiency, an increased emphasis was placed upon the lecture format. The decline in the use of the laboratory as a teaching technique was felt to be undesirable in the education of medical students. Accordingly, a system was developed which presents actual specimen materials in a format which retains the immediacy of the traditional laboratory and yet is more economical of the time of both students and instructors. The basis of this system is a series of self-instructional stations which use laboratory material as an integral part of the teaching–learning process.

Studies evaluating the effectiveness of self-instructional teaching techniques have stressed the use of alternatives to specimen material. Stereo slides were used in place of gross dissection (Kahn, Conklin & Glover, 1973); microfiche replaced microscopic slides (Prentice *et al.*, 1977); or audio-visual materials replaced laboratory experiences (Metcalf & Moffatt, 1972). The laboratory station approach described in this article contrasts with the above examples by retaining specimen material and incorporating it into the teaching programme. Discovery, feedback, and reinforcement are provided by the specimen as well as the written material. This approach retains the direct experiences of a laboratory but additionally introduces the power of guided, self-instructional techniques.

Methods

To implement and test the effectiveness of this concept six laboratory stations were developed each of which covered a specific topic in neuroanatomy. Instructional objectives were stated for each station

and an organized sequence of explanations, examples, manipulations, questions and answers was conceived to fulfil the objectives. In addition to designing experiences which would achieve the instructional objectives, several criteria were imposed which governed the more mechanical aspects of station design. Packaging, time to completion, accessibility and station format all presented limitations to be considered. The result of this process was a series of compatible stations which are consistent in overall format and yet different in the specific tasks required of the student.

Two facets of the laboratory stations were evaluated: (1) effectiveness of presentation for content mastery and (2) acceptance of this form of laboratory approach by the students. To evaluate the effectiveness of the stations, examinations were prepared which measured the achievement of the stated objectives. To assess student acceptance, questionnaires probed the students reactions to the method of presentation.

Only three stations were selected for this evaluation since the tests were not to be used for grading purposes and examination time had to be extracted from laboratory time. The results of the evaluations of these stations are considered to indicate the general quality of all stations.

For each of the three stations, a twenty-question examination was constructed. Ten of the questions assessed the stated objectives of that station and ten questions assessed the student's ability to apply the neuroanatomical principles to clinically relevant situations. The examinations were administered to volunteers from the first-year medical student class 5 weeks after completion of the station.

Design and implementation

For the laboratory stations to be effectively implemented, their design had to be responsive to the limitations and objectives of the subject matter to be taught, and to a teaching situation with a student-to-teacher ratio as high as 100 to 1. Consequently, each laboratory station is limited to few concepts, is able to be completed within 20 minutes, requires no other station as a prerequisite, and utilizes specially prepared specimen material as an integral part of the teaching–learning programme. The topics of the six stations developed for this study are: (1) Horizontal Brain Slice, (2) Internal Structures of the Forebrain in Horizontal Section, (3) Ventricular

Sytem, (4) Cranial Nerves, (5) Areas of the Brainstem, and (6) Lobes of the Forebrain: Lateral Surface.

Each of these stations uses a different technique to introduce the material and yet each station is packaged and presented in the same format. For example, in Lobes of the Forebrain: Lateral Surface, the student first identifies the boundaries of the several lobes, and then identifies features on the brain, verifying their identification by referring to numbered pins on the specimen. In this manner the student learns the features which identify the lobes and develops a sense of scale and orientation on the actual brain. In the Cranial Nerves station, on the other hand, the student is required to identify the cranial nerves on a rubber model and then on a real brainstem. After identification, a series of tables are completed on which the student lists location, name, and function of the cranial nerves.

Each station clearly states purpose and objectives followed by a summary of prerequisite information necessary for completing the station. Next, directions are given for the performance of the station. These include procedural instructions along with informational material. A sample of the format of one station, Areas of the Brainstem, is given in Figs 1a—1d. An instructor's guide sheet (Fig. 1a) gives the materials needed for the station and outlines all set-up procedures. The instruction sheet (Fig. 1b) tells the student how to proceed and the answer sheets (Figs. 1c and 1d) provide corrective feedback.

In order to accommodate as many as 200 students in a single laboratory session, the stations are designed to be performed in any order and to take approximately the same length of time to complete. Six replicates of each station are provided thus allowing all 200 students to use the stations simultaneously.

Results

Student response to this teaching format was favourable (Fig. 2). More than 98 % of the students responding found the stations interesting, well organized, and clearly written with teaching techniques appropriately matched to the topic. In some station replicates a self-quiz was included. Ninety-nine percent of the respondents felt that the quiz was a valuable addition to the station. Ninety per cent ($n = 181$) indicated that the level of difficulty of the stations was appropriate for their degree of

(a)

INSTRUCTOR GUIDE SHEET #5   AREAS OF THE BRAINSTEM

Pin Locations:
- model
1. superior colliculus
2. pyramid
3. nerve V
4. basis peduncle
5. nerve IV
10. olive
- specimen
2. pyramid
4. basis peduncle
6. aqueduct of Sylvius
7. midbrain tegmentum
8. superior medullary velum
9. pontine tegmentum
11. IV ventricle of pons
12. IV ventricle of medulla
13. medullary tegmentum
14. inferior colliculus
15. inferior medullary velum

Necessary Materials:
*midsagittal section (pinned)
 pinned as above
*rubber brainstem model,
 pinned as above
*7 colored level/region cards
*15 white structure cards
*instruction sheet #5
*answer sheet #5 (A & B)
 worksheet #5 (1/student)

*Included in box #5

(b)

INSTRUCTION SHEET #5   AREAS OF THE BRAINSTEM

Prerequisite Skills:

An introduction to the structure of the brainstem

Purpose:
To locate specific brainstem structures by identifying the region
(midbrain, pons, or medulla) and the area within each region (roof,
ventricle, tegmentum or base) to which these structures belong.

Objectives:

Given a rubber brainstem model and a midsagittal section of a human
brain,

1. Identify the levels of the brainstem: midbrain, pons, and medulla.

2. Identify the ventral to dorsal regions of the brainstem: roof,
   ventricular space, tegmentum (core), base.

Instructions:

1. On worksheet #5, note the three levels of the brainstem. Locate
   the three levels (midbrain, pons, medulla) on the rubber brainstem
   model and label the diagram.

2. Follow the same procedure as in instruction #1 above with the four
   dorsal to ventral regions of the brainstem [roof, ventricular space,
   tegmentum (core), and base].

3. Check and correct your labels using answer sheet #5 (A).

4. Arrange the colored cards in a matrix with the three levels on
   the left and the four dorsal to ventral regions at the top.

5. The numbers on the white structure cards correspond to the numbered
   pins on both the model and the specimen. Using the information
   from the models, specimen, and cards, divide the cards into four
   piles: roof structures, ventricular spaces, tegmental structures,
   basal structures. Place each card on the matrix in the appropriate
   level of the brainstem.

6. Check your answers on answer sheet #5 (B).

7. Now fill in the spaces on worksheet #5 to correspond to the card
   matrix you've built. Keep your worksheet for future reference.

(c)

ANSWER SHEET #5 (A)   AREAS OF THE BRAINSTEM

(d)

ANSWER SHEET #5 (B)   AREAS OF THE BRAINSTEM

	ROOF	VENTRICLE	TEGMENTUM	BASE
MIDBRAIN	1. Superior colliculus 5. Nerve IV 14. Inferior colliculus	6. Aqueduct of Sylvius	7. Midbrain tegmentum	4. Basis peduncle
PONS	8. Superior medullary velum	11. IV Ventricle (pons)	9. Pontine tegmentum	3. Nerve V
MEDULLA	15. Inferior medullary velum	12. IV Ventricle (medulla)	10. Olive 13. Medullary tegmentum	2. Pyramids

FIG. 1. Sheets 1a–1d, laminated in plastic, are the basis of the laboratory station entitled *Areas of the Brainstem*. 1a is an instructor's guide which details the materials necessary for the station; 1b is the student instruction sheet; 1c and 1d are answer sheets. Also included in this station are numbered and labelled cards which must be put into the correct order by the student, and a worksheet which is completed and kept by the student. A mid-sagitally sectioned brain and brainstem model, each with labelled pins appropriately placed are also provided.

Interesting ($n = 184$)

Organized ($n = 184$)

Clear instructions ($n = 183$)

Quiz valuable ($n = 108$)

Appropriate teaching technique ($n = 177$)

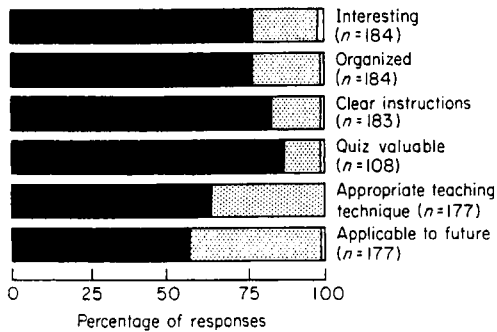Applicable to future ($n = 177$)

Percentage of responses

FIG. 2. Student ratings of the laboratory stations. The three stations were rated together on a three choice scale of yes, somewhat, or no for the six statistics listed. Less than 5% of the students were dissatisfied with these aspects of the technique.

fi, Percentage of 'yes' responses; △ percentage of 'somhewat' responses; ▲, percentage of 'no' responses.

sophistication with 5% indicating that the material was too easy and 5% indicating that it was too difficult. Ninety-eight percent ($n = 178$) felt that they were adequately prepared to complete the stations.

Separate tests covering material from three of the stations were administered 5 weeks after the laboratory was completed. The mean score for the combined tests was 88% correct with the lowest mean for a single station of 81% correct (Table 1). The mean of the scores on the application questions for each test did not differ significantly from the mean of the scores on the content questions ($P \geqslant$ 0·05 for each test).

Although the laboratory experiences were each designed to be completed in no more than 20 minutes, students reported spending between 7 minutes and 1 hour and 40 minutes per station. The average amount of time spent per station for all six stations was 31 minutes.

Instructor time spent in preparing the laboratory

session was found to be much less than required for traditional laboratories. Once the individual stations had been designed and packaged, and the specimen material prepared (before the beginning of the semester), all that remained was to distribute the stations to the rooms in which they were to be used. Subsequent to the initial use of these stations by the first-year medical students, the same stations and specimens were used without further preparation by students in other courses throughout the calender year. In all, the six original stations with six replicates were used by more than 400 students in one year.

One problem in keeping wet specimens usable for prolonged periods of time was overcome by keeping individual dissections or preparations in airtight plastic cake holders. When the brains were covered with wet paper towels and sealed in the cake holders, they remained usable for one full calendar year, serving many students.

Students were allowed access to the stations at times other than the assigned laboratory periods. Many students used the station accessibility to repeat the stations or to review for exams. This feature proved to be quite popular. Approximately 50% of the medical class used at least one station more than once over the semester.

Discussion

Acceptance of these laboratory stations by the students was enthusiatic. Two features might have enhanced this response: (1) using the stations provided a change from the large-class lecture and (2) working with real human brain specimens was novel and exciting. Along with acceptance, of the station format, there was a positive student attitude with respect to the subject matter. The well-defined objectives combined with the teaching instructions

TABLE 1. Results of tests administered 5 weeks after completion of the laboratory stations. The first ten questions tested the students' retention of the station content as defined by the station objectives; the second ten questions tested the students' ability to apply the neuroanatomical principles to clinically relevant problems. Figures are means ±1 s.d. and, in parentheses, percentages of questions answered correctly.

Station	n	Mean score (1st ten questions) content	Mean score (2nd ten questions) application	Total mean score
1	26	8·96 ± 1·28 (90)	9·12 ± 1·31 (91)	18·08 ± 2·43 (90)
2	33	8·43 ± 1·52 (84)	7·85 ± 1·28 (79)	16·27 ± 2·00 (81)
3	15	9·60 ± 0·74 (96)	8·60 ± 1·64 (86)	18·20 ± 2·01 (91)

and specimen material to give the students an insight into anatomical scale and anatomical relationships in a short time.

It must be stressed that these stations were not merely prosections viewed while reading a prepared text. The technique incorporates the specimen itself into the learning experience by requiring the student to use the material in formulating an answer to a question or performing a step in the instructions. This feature is the key to the laboratory station concept.

From the instructor's standpoint these stations provide at least three advantages once they have been designed, tested, and packaged: (1) graduate students can prepare the specimen materials well in advance of the laboratory date, (2) non-professional personnel can distribute the prepared materials on the laboratory day, and (3) the instructor can consolidate concepts or introduce more advanced material during discussions stimulated by the subject matter.

Test results indicate that the stated objectives were satisfactorily met. During the 2-hour laboratory session each student visited six different stations. Thus, even though the objectives of an individual station were limited, many important concepts were introduced in one laboratory period.

A library of laboratory stations is currently being assembled. With these off-the-shelf packages available, individually designed laboratory sessions will be possible by choosing sets of stations which correlate with course content. Implementation of the laboratory station approach has allowed the Neural and Behavioural Sciences course at the University of Michigan Medical School to retain neuroanatomical laboratories in the curriculum.

Acknowledgments

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