Active learning by play dough modeling in the medical profession

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Submitted 27 July 2010; accepted in final form 15 February 2011

Learning the nervous system has always been a difficult task for undergraduate students. In particular, the complexity of the system and the condensed time available present a difficult challenge. Regardless of audiovisual aids (blackboard, PowerPoint presentations, ready-made models, or CD-ROMs), deep learning is difficult to achieve. Therefore, we developed an active learning component to teach about the nervous system based on the Chinese proverb “When I hear, I forget; when I see, I remember; and when I do, I understand.”

Active learning produces meaningful learning, improves attitudes toward learning, and increases knowledge and retention (9), but is still not fully institutionalized in the undergraduate sciences.

A few studies (3, 7, 8) have compared the effectiveness of PowerPoint presentations, student seminars, quizzes, and use of CD-ROMs with blackboard teaching and didactic lectures. In all these studies, it was found that active learning methods made a better impact than passive learning, but the active involvement of all the students was equally lacking. In the literature, we encountered only one study (5) that incorporated the making of clay models by the students themselves, to learn better.

Play dough is an easy to use learning tool that can help students turn both concrete and imaginary things into colorful models. Therefore, the main aim of the present study was to highlight the use of play dough in modeling the nervous tracts and also to compare the outcomes of such active learning by modeling over passive learning in medical students who were undergraduates in the first phase of the Bachelor of Medicine and Bachelor of Surgery program in India. Random selection was done from a class of 100 students. Students were grouped into 2 groups, each composed of 50 students (a control group and a study group). The selection was done by instructing all the 100 students to be seated in the classroom anywhere they wished, and each student was asked to say aloud a number, from 1 to 100, in serial order. The odd numbers constituted the control group, and the even numbers constituted the study group. All students had the same academic qualifications (all of them had passed class XII of the Central Board of Secondary Education in India, with the same curriculum and science as one of the subjects), and there were no statistical differences between the control and study groups with respect to age or sex. Students were informed about the study, and written consent was obtained. Approval was obtained from the Ethical Committee of the institution.

All 100 students were first taught about the different sensory and motor tracts using the blackboard, ready-made models, PowerPoint presentations, and CD-ROMs (passive learning) during a 75-min lecture. Immediately after the lecture, the 50 students in the control group were assessed with a questionnaire of 15 questions, each scoring a maximum of 4 points, making the total maximum score achievable 60 points (Table 1). The answer to each question was given 1, 2, 3, or 4 points, depending on its correctness and depth. The questionnaire was given immediately after class and then again 15 and 30 days later without any further instruction.

Students in the study group were engaged in making models of the sensory and motor tracts under the supervision and guidance of the teachers. Students were first asked to prepare cross sections of the spinal cord, medulla oblongata, midbrain, thalamus, and cerebral cortex, using colored dough, and these sections were either placed on a flat surface or pierced to a steel/glass rod one above the other in that order. Later, students were instructed to make the tracts using dough wrapped around a flexible copper wire with different colored dough for different order neurons. Thus, the lateral spinothalamic tract, anterior spinothalamic tract, dorsal tract, and pyramidal tract were made. The tracts were then either placed or pierced appropriately in their respective places in the different sections of the spinal cord, medulla oblongata, midbrain, thalamus, and cerebral cortex. After finishing the task, students were asked to demonstrate and explain the course of the different tracts that they had modeled. Immediately after this activity, students were assessed by the same questionnaire as in the control group and then again after 15 and 30 days without any further instruction. The activity took an additional 60 min to complete in a time normally reserved for discussion sessions.

Statistically, results were compared between the two groups (the control group and the study group).

Control group scores were named as follows:

- Immediately after passive learning (C1)
- 15 days after passive learning (C2)
- 30 days after passive learning (C3)

Study group scores were named as follows:

- Immediately after active learning/modeling (S1)
- 15 days after active learning/modeling (S2)
- 30 days after active learning/modeling (S3)

The analysis was made by comparing the following pairs of scores by a Wilcoxon’s signed rank test: C1 and S1, C2 and S2, C3 and S3.
and S2, and C3 and S3. The analysis was made by comparing the following pairs of scores by a paired $t$-test: C1 and C2, C1 and C3, S1 and S2, and S1 and S3. The respective $\tau$, $t$, and $P$ values were determined. $P$ values of $<0.05$ were considered significant. The results of the study are shown in Table 2. The results demonstrate that the mean total score in the study group was greater compared with the control group when scores were evaluated immediately after the class, after 15 days, and even after 30 days. There was also less deterioration in the mean total score in the study group compared with the control group when scores were evaluated after 15 days and 30 days.

It is well known that lectures with audiovisual aids and self-study tutorials have a greater impact than didactic lecture alone. Combined passive and active learning methods have an advantage over only passive teaching methods (6), where active learning consisted of gathering information from the library and drafting essays on the topics assigned. Active learning in the form of case studies in physiology was also helpful for students in understanding elementary physiology material given in the form of didactic lectures (7). Improvement was seen in the students’ achievement, motivation, and self-efficacy by active learning techniques such as inquiry-based models and think-pair-share activities (9). Innovative teaching methods such as computer-assisted learning (CD-ROMs), undergraduate projects, seminars, and physioquiz were found to increase pedagogical effectiveness (8).

In the literature, we did find a few studies (1, 2, 4) in which models of various materials were constructed to increase the effectiveness of learning by students. Manipulative material like clay was used in only one study (5) to create ion channels and nerve cells. In these studies, the students showed gains in their knowledge immediately after the activities. Here, we show similar improvements, but also that long-term learning was enhanced.

Although there are a variety of materials available in the market for making models, play dough was used in this study because the models could be made very easily without much time consumption, could be molded in any direction, and were distinctive because of color differentiation. The models may not be long lasting, but they can be done faster, and also any errors in creation of the models can be easily rectified within seconds, and the dough can be reused a number of times for the same purpose.

The PowerPoint presentations and ready-made models may be easily forgotten, and the CD-ROMs may be boring for some students, whereas by making the models, each student was actively involved and was very much interested because it was something away from the books, CD-ROMs, and blackboard. Since almost every student faced difficulty in understanding and retaining the details of the nervous tracts, this topic was chosen for the activity. All the students expressed immense pleasure and gratitude for this activity and wanted the same for other difficult topics as well, which would help them to better understand physiology. Clearly, kinesthetic modes of learning, such as described here, impact short- and long-term learning gains.

**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the author(s).

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**Table 1. Questionnaire**

| Questions | 1. Name the important ascending tracts of the spinal cord. | 2. Name the important descending tracts of the spinal cord. | 3. Name the sensations carried by the lateral spinothalamic tract. | 4. Name the sensations carried by the anterior spinothalamic tract. | 5. Name the sensations carried by the dorsal tract. | 6. Describe the course of first-order neurons of the anterior and lateral spinothalamic tracts. | 7. Describe the course of first-order neurons of the dorsal tract. | 8. Describe the course of second-order neurons of the anterior and lateral spinothalamic tracts. | 9. Describe the course of second-order neurons of the dorsal tract. | 10. Describe the course of third-order neurons of the sensory tracts. | 11. From where does the pyramidal tract arise? | 12. Why is it called the pyramidal tract? | 13. Where do the corticospinal fibers cross? | 14. What percentage of fibers of the corticospinal tract do not cross? | 15. Where do the fibers of the corticospinal tract end? |

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**Table 2. Comparison of mean total scores between the control and study groups as well as their significance**

<table>
<thead>
<tr>
<th>Control group</th>
<th>Immediately After Class</th>
<th>After 15 Days</th>
<th>Study group</th>
<th>Immediately After Class</th>
<th>After 15 Days</th>
<th>Comparison Between Control and Study Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>36.3 ± 4.7, SE = 0.66</td>
<td>31.3 ± 6.1, SE = 0.86</td>
<td>S1</td>
<td>54.5 ± 4.3, SE = 0.61</td>
<td>51.4 ± 5.9, SE = 0.84</td>
<td>$t = 18.7, P &lt; 0.001^*$</td>
</tr>
<tr>
<td>C2</td>
<td></td>
<td></td>
<td>S2</td>
<td></td>
<td></td>
<td>$t = 13.4, P &lt; 0.001^*$</td>
</tr>
<tr>
<td>C1 with C2</td>
<td></td>
<td></td>
<td>S1 with S2</td>
<td></td>
<td></td>
<td>$t = 11.2, P &lt; 0.001^*$</td>
</tr>
<tr>
<td>C3</td>
<td></td>
<td></td>
<td>S3</td>
<td></td>
<td></td>
<td>$t = 10.1, P &lt; 0.001^*$</td>
</tr>
<tr>
<td>C1 with C2</td>
<td></td>
<td></td>
<td>C1 with S1</td>
<td></td>
<td></td>
<td>$z = 6.17, P &lt; 0.001^*$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2 with S2</td>
<td></td>
<td></td>
<td>$z = 6.16, P &lt; 0.001^*$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C3 with S3</td>
<td></td>
<td></td>
<td>$z = 6.16, P &lt; 0.001^*$</td>
</tr>
</tbody>
</table>

*Highly significant.
REFERENCES