# Does computer modeling with an interactive user interface improve learning?

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**Key Points:**

- **Computer modeling and interactive user interface has been shown to improve student learning outcomes for complex information in science, technology, engineering, and mathematics education.**
- **The evolution of technology challenges the educational system to update teaching strategies to optimize learning for 21st century students.**
- **Because the benefits of computer modeling to improve student outcomes have not been fully established, we assessed whether an interactive and 3-dimensional (3D) computer brain program enhances student test scores in an undergraduate neuroanatomy course.**

The evolution of technology, especially computer technology, has created an impact on education and how students learn and absorb information. Society has transitioned from its early chalkboard beginnings to hands-on simulations involving 3D-printed models or computer-generated learning tools. Such tools and models allow students to view, interact with, and modify objects that are too small, complex, or abstract to visualize for optimal learning. This type of manual interaction has been shown to increase knowledge retention and comprehension[4].

While technological learning tools remain an area with relatively little research, there is evidence that supports these tools are improving learning comprehension at a rapid pace and student motivation. First, these tools use visuals combined with graphics and text that is similar to the growing ubiquitous use of personal devices such as cell phones, tablets, and laptops[2]. Graphic- and image-based learning has been demonstrated to increase student learning outcomes and student motivation (Fig 1), and the recent introduction and explosion of social media modalities illustrate the rapid adoption of this type of medium. Second, interactive compared to static tools allow students to reinforce their learning through repetition and exploration at their own pace and design in a form that allows students to comprehend information at a rapid speed[3]. A study conducted out of MIT demonstrated that active learning where

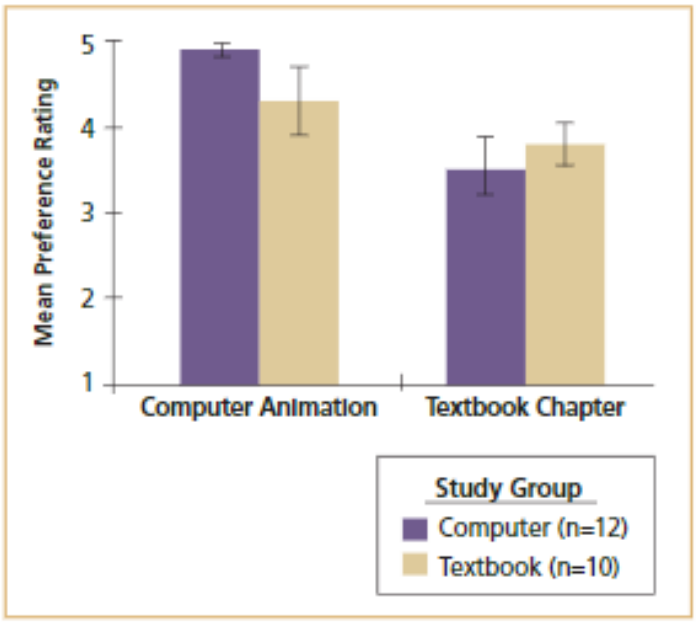


**Figure 1**: Compared student preferences for learning after an examination of students who used the computer animation learning tool versus a hard copy textbook[7].

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professors led interactive simulation run-throughs or hands-on activities produced increased student comprehension for college-level students in several different courses compared to standard lecture-style teaching and interaction[1]. Additionally, animated visual learning results in improved exam performance over static visual learning in terms of applying concepts, procedures, and principles of DNA replication (Table 1)[6]. Lastly, interactive computer-based tools have been shown to allow students to develop independent learning skills by permitting self-pacing and immediate feedback of their efforts[5]. While interactive learning has been shown to improve academic performance, it has the added benefit of increasing student motivation and genuine interest in learning. Currently, an important question remains which is whether a combination of these benefits of computer technology will improve student engagement and, ultimately, learning outcomes.

**Table 1**: Average scores of different classes using a variety of learning techniques. The techniques compared included a "verbal" and "visual" learning style for both an animated, or computer aided simulation, and a static, also commonly known as textbooks or vocal lectures. The overall result of this study was that the visual, computer aided simulation, resulted in the highest performing students[6].

| Treatments | Learning Styles | Total of Students (n) | Capability of applying concepts | | Capability of applying procedures | | Capability of applying principles | |
|---|---|---|---|---|---|---|---|---|
| | | | Average score | Standard deviation | Average score | Standard deviation | Average score | Standard deviation |
| Static Visualization | Visual | 47 | 51.8 | 14.46 | 40.8 | 12.76 | 37.5 | 12.72 |
| | Verbal | 21 | 51.9 | 16.00 | 41.9 | 13.23 | 37.7 | 13.03 |
| Animated Visualization | Visual | 37 | 60.3 | 13.84 | 48.8 | 14.64 | 46.4 | 15.80 |
| | Verbal | 33 | 56.5 | 14.76 | 46.8 | 15.28 | 42.6 | 15.02 |

We anticipated that combining computer modeling with an interactive user interface to establish a strong understanding of human neuroanatomy would have a positive effect on exam scores, student excitement and motivation for the material, and allow students to learn in an engaged and self-driven manner. Our early findings have encouraged this hypothesis to be true. One artifact of evidence that enhances these anticipations is that students have viewed our WebGL site in bulk before exams and they have filled out surveys concluding that the tool has been resourceful and encouraged them to study due to its visual and interactive appeal. Our quiz mode has allowed students to also process immediate feedback which allows us to compare test scores between prior years to this year. These test averages showed that students did in fact perform higher overall using the WebGL tool and that comprehension could possibly be developing at a faster pace (Fig 2). Although the difference is small, these data prove that developing interactive learning tools may allow students to grasp information at a more rapid pace and with a deeper understanding.

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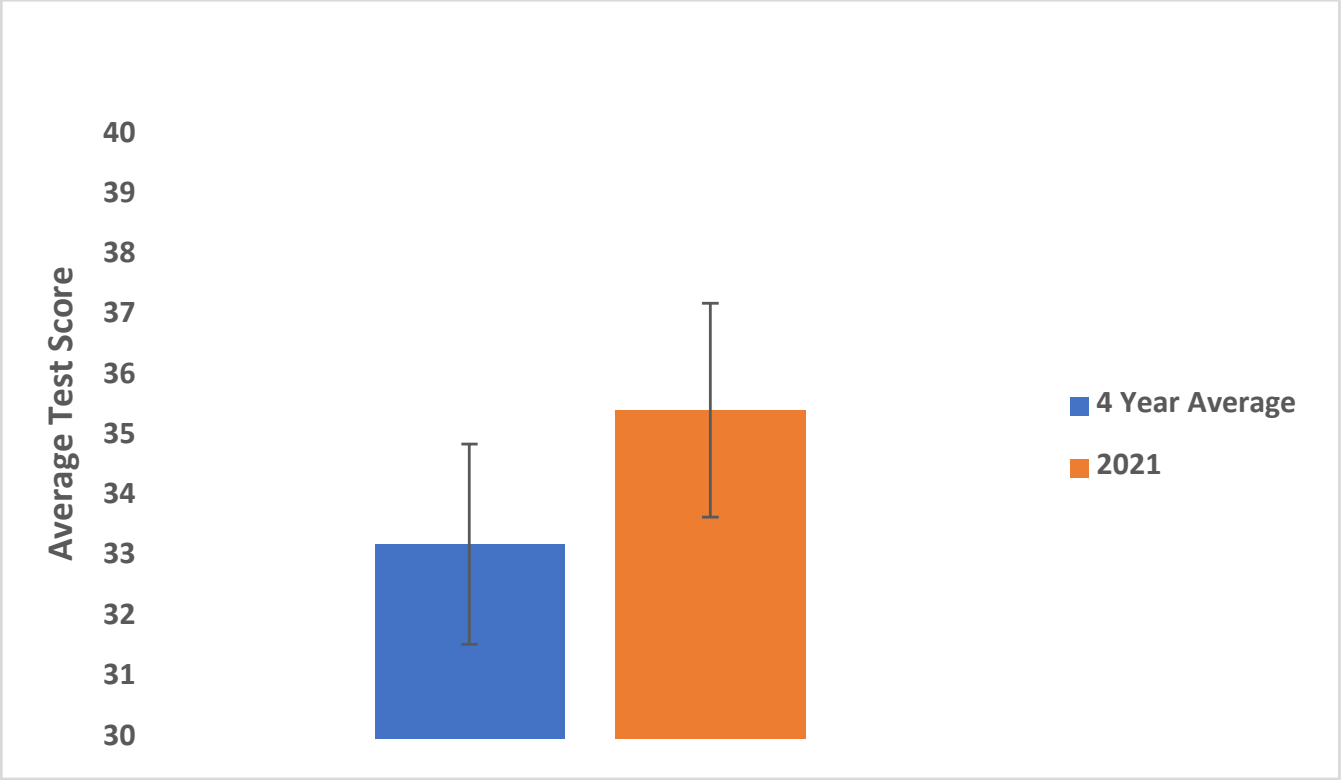


**Figure 2**: Average test scores from the past four years of Dr. SuJean Choi's course compared to this year's average test score using the Neuroanatomy tool.

## References

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