A Comparative Analysis of Student Learning with a Collaborative Computer Simulation of the Cardiopulmonary System

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Abstract

To design a series of assessments that could be used to compare the learning gains of high school students studying the cardiopulmonary system using traditional methods to those who used a collaborative computer simulation, called "Mr. Vetro". Five teachers and 264 HS biology students participated in the study. The students were in regular biology, advanced biology, anatomy and physiology or AP biology. One group of teachers taught a 7 day unit on the cardiovascular system using Mr. Vetro and the other group of teachers taught the same content without Mr. Vetro. Assessments were administered before and after the unit, and included basic recall as well as making connections and application of knowledge to new situations. The learning gains of four matched Vetro vs. Comparison groups were compared, for all types of assessments. Results indicate that there were statistically significant differences between the learning gains of all of the Vetro vs Comparison groups for assessments that required higher level thinking skills as well as for some of the assessments that required basic recall. Learning gains on multiple choice problems taken from standardized tests were more moderate or not significant. Results show that students who use the Mr. Vetro collaborative computer simulation make stronger learning gains than those who do not, regardless of the level of the course. Schools should consider using the Mr Vetro simulation to foster a deeper understanding of the cardiovascular system. (Contains 2 Figures and 1 Table).

Objective

To design a series of assessments that could be used to compare the learning gains of HS students studying the cardiopulmonary system using traditional methods to those who used a collaborative computer simulation, called "Mr. Vetro" (Ioannidou, et.al, 2010, Repenning, et. al, 2005).

Conceptual Framework

We predicted that students in the Mr. Vetro group would show higher achievement gains than those in the comparison group, because the computer simulation promotes collaboration between students as they control Mr. Vetro's organ parameters (Ioannidou, et.al, 2010, Repenning, et. al, 2005). The simulation demonstrates the relationship between the cardiovascular system and pulmonary system that is difficult to demonstrate otherwise.

Assessments included three "Levels of Thinking" (Shafer and Foster, 1997):

- Level I questions assess the recall of basic facts and/or development of skills.
- Level II questions involve making connections and/or integrating of information.
- Level III questions involve analyzing, interpreting and/or applying knowledge in new situations.

Methods
Both groups had between 5 and 7 days of instruction on the cardiopulmonary system (Luhn, 2010).

The Mr. Vetro treatment group was comprised of three teachers and 169 students in nine classes. The Mr. Vetro treatment group used the computer-based simulation with related activities. Some examples of simulations were an elite athlete and a smoking Mr Vetro exercising and a "normal" Mr Vetro overdosing on caffeine or valium (Luhn, 2010).

The comparison group was comprised of three teachers and 95 students in five classes. The comparison group used traditional methods for teaching the same learning objectives. Some examples of activities were students exercising and then measuring their own heart rate, and traditional lecture-style lesson (Luhn, 2010).

Students in both groups completed written assessments just prior to and just after the unit.

Data Sources
The Level I questions in the written assessments were selected response, marked as correct (1 pt) or incorrect/no response (0 pts). Level I questions included selecting typical values for "at rest" heart and lung parameters and oxygen saturation (i.e., heart rate, breathing rate). They also included multiple-choice questions that were collected from various conventional assessments (AP Biology Exam, NY State Regents Exam, Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), National Assessment of Educational Progress (NAEP), and the Scholastic Achievement Test (SAT). The multiple choice questions were chosen as best fit to the curriculum.

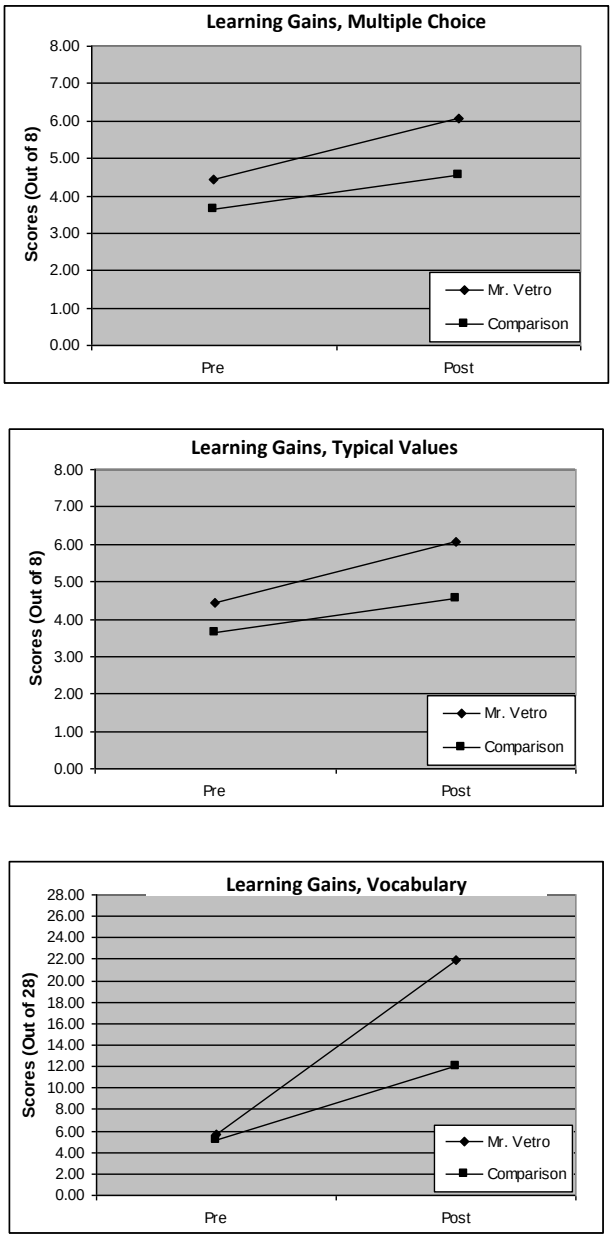
The Level II & Level III questions were open response, and were graded on 0-4 point rubric developed by design team. The Level II questions were definitions of vocabulary words used throughout the unit (i.e., hyperventilation, oxygen saturation, hypoxia, etc). The Level III questions, which were only administered in the post-assessment, involved applying knowledge learned in the classroom to a novel scenario. (i.e., what happens to parameter when mountain climber exercises at altitude or when a person has coronary artery disease?)

Results
Only students who took both the pre-assessment and the post-assessment are included in the data. Independent two-tailed t-tests and effect sizes were calculated.

Aggregate Comparison. An aggregate comparison was made between the learning gains (difference between pre and post assessment results) of the entire Mr. Vetro group ($n = 169$) vs. the entire comparison group ($n = 95$). See Figure 1. In all Levels of assessments, the learning gains of the Mr. Vetro group were significantly greater than those of the comparison group. (multiple choice, $t(205) = 1.97$, $p < 0.001$; typical values, $t(226) = 1.97$, $p < 0.001$; vocabulary, $t(184) = 1.97$, $p < 0.001$). Respective effect sizes were 0.42, 0.99, and 1.42. The Mr. Vetro group differed significantly from the Comparison group in the multiple choice pre-assessment scores.

There were more advanced students in the Mr. Vetro group as a whole.

Figure 1: Aggregate Results, Learning Gains of Mr. Vetro vs. Comparison



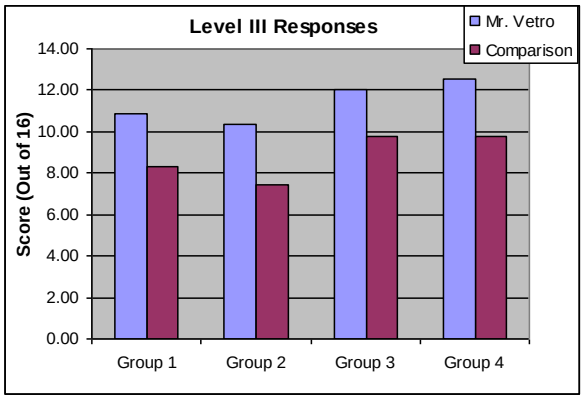
Comparison of matched groups. Four matched groups of Mr. Vetro vs. Comparison classes were then selected for further analysis. For the four matched groups, differences in responses to Level III tasks were statistically significant in favor of Mr. Vetro (Group 1: $p < 0.05$, Groups 2-4: $p < .001$). Respective effect sizes were 0.69, 0.76, 1.04 and 0.98. See Table 2 and Figure 2.

Table 1: Description of Matched Vetro vs. Comparison Groups

Group #	Description	Group Type*	Teacher	School	# of Classes	# of students	Type of Class
1	Same teacher at same school teaching same course	V	A	A	One	17	Regular Biology
		C	A	A	One	12	Regular Biology
2	Two different teachers from different schools teaching same course	V	A B	A B	One One	44	Regular Biology
		C	A C	A C	One Two	57	Regular Biology
3	Two different teachers from different schools teaching same course	V	D	C	Two	29	Anatomy & Physiology
		C	E	B	Two	38	Anatomy& Physiology
4	Two different teachers from same school teaching advanced students (mixed class type)	V	B	B	Three	85	2 AP Bio, 1 Adv Bio
		C	E	B	Two	38	Anatomy & Physiology

V = Mr. Vetro Group, C = Comparison Group

Figure 2: Post-Assessment Results of Level III questions, Matched Mr. Vetro vs. Comparison Groups



The learning gains of the responses to the Level I multiple choice questions were not notable. Groups 1 and 3 had no statistical difference and had very small effect sizes. The other two were statistically significant ($p<0.05$) and the effect sizes were small to moderate (0.44 and 0.58).

The learning gains of the responses to the Level I typical values questions were statistically significant in favor of Mr. Vetro for all matched groups (Groups 1, 3 and 4: $p<0.001$, Group 2: $p<0.05$). The effect sizes were large to very large (0.65 to 1.06).

The learning gains of the responses to the Level II vocabulary questions were statistically significant in favor of Mr. Vetro for all matched groups (Groups 2-4: $p<0.001$, Group 1: $p<0.05$). The effect sizes were large to very large (0.81 to 1.60).

Conclusions/Significance

The comparison of pre- post-unit responses to the assessments demonstrates that the Mr. Vetro tech-based collective simulation approach, for similar content, results in stronger learning gains for all groups regardless of the level of the course (e.g., regular or honors). Statistically greater gains occurred in the results of Level I recall of typical values of the heart and lung parameters and in Level II vocabulary definitions. Differences in the gains in Level I recall of multiple choice questions from conventional assessments were more moderate, or in some matched groups, not significant. It is notable that responses to post-assessment Level III questions, which require critical thinking and application, were significantly more complex in the Vetro groups than those in the matched Comparison groups.

The Mr. Vetro collaborative computer simulation shows promise as a tool for students to have steeper learning gains of the cardiopulmonary system.

References

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