Shock and awe pedagogy!

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Galen of Pergamon (130–200 A.D.) was an accomplished showman and scientist who made enormous advancements in the understanding of the heart, nervous system, and mechanics of breathing. These advancements were often achieved during impressive public “performances” of vivisection on Barbary apes and other living animals. He designed his public “shock and awe” spectacles like mystical shows with the goal of amazing his awestruck audience. He would marvel and astonish his fascinated audience as they witnessed the anatomic and physiological mysteries of living animals. Galen’s spectacular and marvelous anatomic performances looked less like an intellectual class and more like a magic show or perhaps modern bullfight (6). Galen’s “shock and awe” pedagogy has a long and successful, history having persisted for centuries. The success of this unique pedagogy may be attributable in part to a powerful emotional connection. Basic emotions, including shock, anger, fear, and sadness, are shared by all humans. When we experience emotion in our lives, we tend to remember the experience. In fact, the more emotional impact an experience has, the more intensely we remember its details and the more likely it will be stored in long-term memory.

To enhance learning and retention through Galen’s shock and awe pedagogy, we developed a short inquiry-based “virtual” experiment investigating the “alkaline tide” during the gastrointestinal (GI) section of a team-taught, lecture-based graduate physiology course. The GI section was taught using physical models (8, 10), demonstrations (9), and educational games (1, 4, 11) to engage students and enhance learning and retention. This lecture-based, as opposed to laboratory-based, virtual experiment required little additional class time and minimal preparation. This activity was also institutional review board exempted because it was not considered research and was considered an activity conducted in established or commonly accepted educational settings involving normal educational practices.

To begin our large lecture-based graduate physiology class of 80 students, we introduced the pioneering work of Roger S. Hubbard and “virtually” replicated part of Dr. Hubbard’s original experiment using rats during our discussion of gastric secretions (7, 9). Specifically, Hubbard and Munford (7) demonstrated that the urine of control subjects becomes more alkaline after a standard meal, whereas the urine of patients with achlorhydria (a condition where the production of hydrochloric acid in gastric secretions of the stomach is absent) showed no increase in alkalinity after a meal. The investigators concluded that the secretion of hydrochloric acid by the stomach was the cause of the increased alkalinity of the urine after a meal.

To “virtually” replicate part of the experiment demonstrating how the secretion of hydrochloric acid by the stomach caused an increased alkalinity of the urine, two intact, conscious rats with previously implanted intraperitoneal catheters from our laboratory investigations were introduced to the class. The students were “told” that the catheters were implanted in the stomach. Subsequently, infusion lines were connected to these catheters. The students were also “told” that one rat was receiving a “high-protein solution” and that the other rat was receiving an equal volume of saline via an infusion pump. The students were also “told” that the instructor did not know which rat was receiving each solution.

Next, we began the discussion of the mechanism of H+ secretion by gastric parietal cells (9). The students were shown that the apical membrane of the cell, which faces the lumen of the stomach, contains an H+-K+-ATPase (the proton pump). Furthermore, the basolateral membrane, which faces the blood, contains the Na+-K+-ATPase and a Cl–HCO3– exchanger. Inside the parietal cell, CO2 and H2O combine to form H2CO3, which dissociates into H+ and HCO3–. The H+ is secreted into the lumen of the stomach by the H+-K+-ATPase acidifying the stomach contents to help with digestion of dietary proteins.

The HCO3– is exchanged for Cl– across the basolateral membrane and is thus absorbed into gastric venous blood (the “alkaline tide”). Eventually, this HCO3– is secreted into the lumen of the small intestine (through pancreatic secretions), where it neutralizes the acidic chyme delivered from the stomach. In addition, some of this HCO3– is filtered into the urine.

The alkaline tide, i.e., the absorption of HCO3– by the gastric venous blood, can be observed by an increased alkalinity of the urine. Accordingly, at the end of the discussion (~45 min), the instructor placed a previously filed container of saline into the first rat’s cage and, slightly out of view of the students, pretended to gently express the rat’s urinary bladder collecting “urine” into the container. Next, the instructor placed a previously filed container of saline spiked with HCO3– into the second rat’s cage and, slightly out of view of the students, pretended to gently express the rat’s urinary bladder collecting “urine” into the container. Note that the students thought the containers were initially empty (i.e., they did not know that the containers were previously filled).

The instructor then, in full view of the students, dramatically and deliberately drank both containers of “urine” and “told” the students that he could determine, based on the taste of the rat’s “urine”, which rat received which solution. To confirm the instructor’s ability, by drinking the rat’s “urine”, to determine which rat received which solution, the pH of rat’s “urine” was determined using standard pH test strips. As staged and predicted by the taste test, the rat receiving the “protein solution” had an increased alkalinity of his urine, whereas the rat receiving the saline had no change in “urine” pH.
Based on their horrified expressions and groans of disgust and revulsion, as well as the level of discussion, it was clear that students were engaged and learned about the digestive processes by participating in this virtual experiment. To this day, students comment that they understand and will never forget the “alkaline tide.” In this context, it is important to remember that the teachers’ first responsibility to their students is to focus on learning. However, appropriate “shock and awe pedagogy” that is relevant to the instructional material attracts and sustains attention and provides a brief break that lightens the mood and makes the learning process more enjoyable, memorable, and impressive. In addition, this demonstration, by engaging students and provoking discussion, may increase interactions between students and peers and students with teacher, all of which increases attention and motivation while reducing anxiety and stress.

Galen’s anatomic demonstrations on living animals may constitute the first attempts at “shock and awe pedagogy.” The demonstrations’ spectacular cognitive and emotional impact produced an amazed audience (6). The emotional impact of Galen’s anatomic performances enhanced the learning experience because the shock value created a memorable experience. We used Galen’s approach and believe we obtained similar results. Accordingly, this “experiment” with revelation of the “illusion” became a catalyst for discussion and study and to this day provokes comments and conversations of how tasting urine was once the number one way to diagnose pathology and forecast the future. We had never used this shock and awe demonstration before we unveiled it in the winter of 2016. However, we have used a variety of demonstrations previously (2, 3, 5, 10, 12) and can state unequivocally that none of these earlier demonstrations have received the same dramatic response. Thus the success of this pedagogy may open the way to similar memorable pedagogical experiences that are common to medical education.

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

AUTHOR CONTRIBUTIONS
H.L.L. and S.E.D. conception and design of research; H.L.L. and S.E.D. performed experiments; H.L.L. and S.E.D. interpreted results of experiments; H.L.L. and S.E.D. drafted manuscript; H.L.L. and S.E.D. edited and revised manuscript; H.L.L. and S.E.D. approved final version of manuscript.

REFERENCES