LET THE STUDENTS SURPRISE YOU

"What It's Like to Be a Pioneer"

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Teachers are often amazed at how much their students can do when they are engaged in a lesson using system dynamics. For the students the lesson is just fun. For the teachers, however, it is an enlightening experience to see students display a depth of understanding and enthusiasm that the teachers would not have thought possible. Teachers who use system dynamics in their teaching say that one such experience was enough to get them going.

One example is a third grade lesson in Carlisle, Massachusetts. Third graders study the extinction of the wooly mammoths as part of a science/social studies unit on the ice ages. Math became part of the unit when teacher Gene Stamell added a dice and graphing game. With 20 dice representing a herd of mammoths and certain numbers on the dice representing births or deaths, teams of students roll the dice and graph their herd's population over time. Gene suspected a "systems" application, so he approached Waters Grant systems mentors Alan Ticotsky and Rob Quaden with the idea. Gene had been introduced to system dynamics, but he had never used a model. Alan and Rob had used models with older children, but never with third graders. Together, they built a simple STELLA model of the mammoth population based on the hands-on dice game and gave it a try in Gene's class. Then the kids surprised everyone.

These are some of the things the students could do after they played the dice game and used a system dynamics model to experiment with other birth and death probabilities:

- Students could read the behavior over time graphs produced by the computer model. They could extrapolate to determine the size of the herd for any time on the graph, even when the vertical scales changed or when the values were in scientific notation.
- Students readily interpreted the graphs, using the language of graphing. They could tell if the population was increasing or decreasing over time. Furthermore, they saw that a population with a "steep" rate of decline would become extinct sooner than one with a "flatter" rate of decline. They *wanted* to figure out what the graphs said.
- Students could make predictions and test their hypotheses on the model. They tried many different birth and death rates. It didn't take long for them to accurately predict that the population grows when births exceed deaths and declines when deaths exceed births. When someone suggested making births equal to deaths, they could see that the population would remain unchanged.
- After experimenting with varying death rates, students could discuss the effect of human hunters on the final demise of the mammoth population.
- Students grasped the concept of probability, at their own level. When they played the dice game, students learned that if one number on the dice represented a death, then there was a one out of six chance of death. When they used the model, students were able to change those probabilities. They understood that two out of six, for example, meant a higher probability of death. Following the concrete dice game, most students were able to make that abstract leap.
- As they played with probabilities, students also reinforced their understanding of fractions. Two out of six, or 2/6, is the same as one out of three, or 1/3, for example.
- Students worked cooperatively in groups to solve problems. There were fewer of the usual group dynamics issues because the students were busy working.

These were all impressive accomplishments for eight and nine-year olds in their first exposure to modeling, but the students' understanding of exponential decay really "blew the teachers away." The class was discussing how the mammoth population kept going extinct whenever deaths were greater than births, at any level. Someone pointed out that the computer model had only 100 mammoths in the initial herd. Would it be different if they started out with 1000 mammoths instead? Could they avoid or delay extinction that way? Everyone scratched their heads, including Gene who had never thought about the problem in that way. Students guessed that the mammoths would last ten times longer. Then, one child eloquently hypothesized in his own words that if one out of three mammoths died each year, it didn't matter how many there were to start because one out of every three would still die every year; half the population would be gone by the same time, and the whole population would go extinct by the same time! Then they ran the model, and, sure enough, he was right! Gene was sold! With a little bit of discussion and a few more runs, most of the class understood exponential decay and half-life at their own level, without using those terms specifically. Remarkable!

There were a few issues with the mammoth lesson, however. Some had to do with developmental readiness. For example, although the teachers explained at length that the games were "models" of the mammoth population because they could not grow and count real mammoths in class, a few students had trouble with this concept. One young child rigged her dice to prevent any of her animals from dying! Other children had problems with probability because they believed that 1/6 meant exactly one out of six every time, and they needed reassurances about averages. Teachers always need to pay attention to developmental levels in class, but it is also an important concern for system dynamicists preparing curriculum for elementary grades. Every new lesson teaches us more.

Another issue has to do with the difficulty of introducing a lesson like this in a school. Gene had been introduced to system dynamics and he had used behavior over time graphing with his class, but he probably could not have developed the modeling lesson without the help of Alan and Rob, the systems mentors. After the lesson yielded such positive outcomes for kids, Alan and Rob helped three other third grade teachers adopt it too. Each time they worked out a few more glitches, and each time the new teachers were able to conduct the lesson more on their own. Finally, Gene, Alan, and Rob wrote the lesson up under the Gordon Stanley Brown Fund for other teachers to try. ("The Mammoth Extinction Game" is available through the Creative Learning Exchange at http://sysdyn.mit.edu/cle/.) It is a risk to try something new and it takes time to learn new skills. It goes best when teachers work together to share moral support, expertise, and successful lessons.

Jay Forrester has suggested that we could speed the spread of learner-centered-learning and system dynamics in K-12 education by sharing tales of "what it's like to be a pioneer." It might help others who are starting out, or just curious, to know about other teachers' experiences, positive student outcomes, pitfalls, political issues, responses of administrators and fellow teachers, student and parent feedback, triumphs and tribulations. Forrester has long experience in pioneering, first as an early inventor of the digital computer, then as the founder of system dynamics, and now as an education reformer. This paper presents just one little vignette. Please let me know (LyneisD@cle.tiac.net) if you have other tales to share. Thanks.