

# Measuring Inquiry Cycles in Simulation-Based Learning Environments

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## Introduction<sup>1</sup>

The project "An Inquiry-Based Simulation Learning Environment for the Ecology of Forest Growth" consisted of three main stages of approximately one year each: software development, curriculum development, and classroom implementation. We evaluated the software, called SimForest, in clinical and college classroom settings, then ran a professional development program to support eight secondary school teachers in incorporating the software and curriculum into their classes. This paper focuses on our results from the clinical and classroom trials in which we observed students working in pairs using the software.

SimForest is a simulation-based learning environment in the domain of forest ecology that simulates tree and forest growth, the succession of tree species over time, and the effects of environmental and man made disturbances on forest growth (see Figure 1). In the simulation students set environmental parameters such as rainfall, temperature, soil fertility, soil texture, and soil depth; they plant a plot of trees from a list of over 30 species; and they "run" the simulation and observe the trees as they grow and the forest evolves. A forest plot's sensitivity to natural and man-made disturbances can be evaluated, and emergent properties such as species succession can be observed.

## Method and Results

This professor is considered an expert in inquiry-based science teaching methods, so the study was in part a case study of "best practice" performance. 51 college students who used SimForest in class or mock-class situations. We used two methods to track stages in the inquiry cycle as students engaged in SimForest activities, one global, and one local. At the local level we tracked the individual steps in the inquiry cycle. We taped four pairs of students using the software and analyzed video tapes of student sessions to code for inquiry cycles (see Figure 2).

The approximately one-hour sessions were divided into naturally occurring "episodes" of varying length, averaging about 2 minutes per episode. Table 1 shows a sample of the data. Examination of the data tables leads to the following conclusions: 1) One can clearly see the

occurrence of inquiry "cycles" in the data. The cycles do not always include all of the normal steps of inquiry, but there is a clear pattern. 2) Most of the cycles do not involve posing a new hypothesis, but rather students start a new experiment after making a verbal observation or conclusion, or after realizing they need to redesign the experiment to obtain the results they desire. 3) The average inquiry cycle is approximately 10 minutes in length.

Episode-->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
<b>SESSION A:</b>																		
Ask question																		
Refine question	x																	
Make hypothesis		x																
Plan experiment		x																
Set-up experiment			x					x		x		x		x				
Run Simulation			x					x		x		x						
Record data																		
Verbal observations				x					x		x		x		x			
Refine Method					x				x		x		x		x			
Data analysis	x					x												
Summarize																		

The second method of measuring inquiry cycles was to analyze the flow of class activity. Specifically, we noted how many times the class cycled between small-group inquiry activities on the computer and whole class discussions. Analysis of classroom observation notes revealed how the class organized into cycles of divergent individualized work and convergent full-class discussions.

The sessions lasted 1 to 1.5 hours and on the average the instructor cycled between whole class and independent work about 4 times or every 20 minutes. The inquiry steps mentioned in the first method above occur within these larger grain sized episodes. I.E. once the students began their independent work they usually went through several inquiry cycles before the class was brought together again.

Students were able to engage in about one to 3 inquiry cycles for each larger classroom cycle. Though this data is specific to the particular simulation used and the methods used by the instructor, we can draw some tentative conclusions, in part because . We see "20 minutes" and "1 to 3 inquiry cycles" as a measure of how "far" into independent work the instructor let the students go before bringing everyone together to synthesize what was discovered and giving those who might be stuck the opportunity to ask questions in a full class context.

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