Evaluation of "Dragoon": A Systems Modeling Intelligent Tutoring Tool

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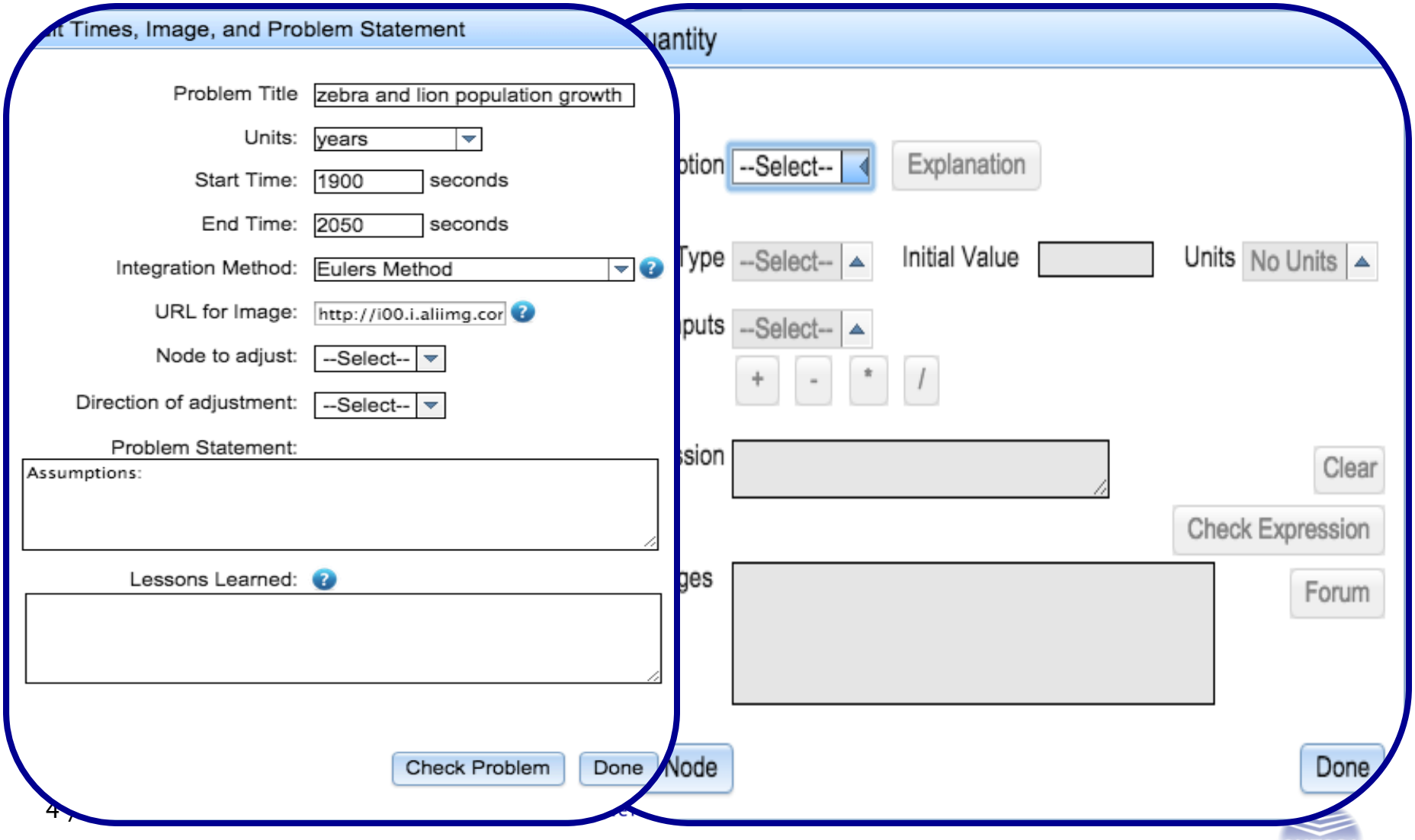
Purpose and Goals

- To evaluate Dragoon-based instruction
  - ✓ *To what extent does Dragoon impact learning of domain content and skills in authentic classroom settings?*
  - ✓ *How do students perceive the features and use of the system?*

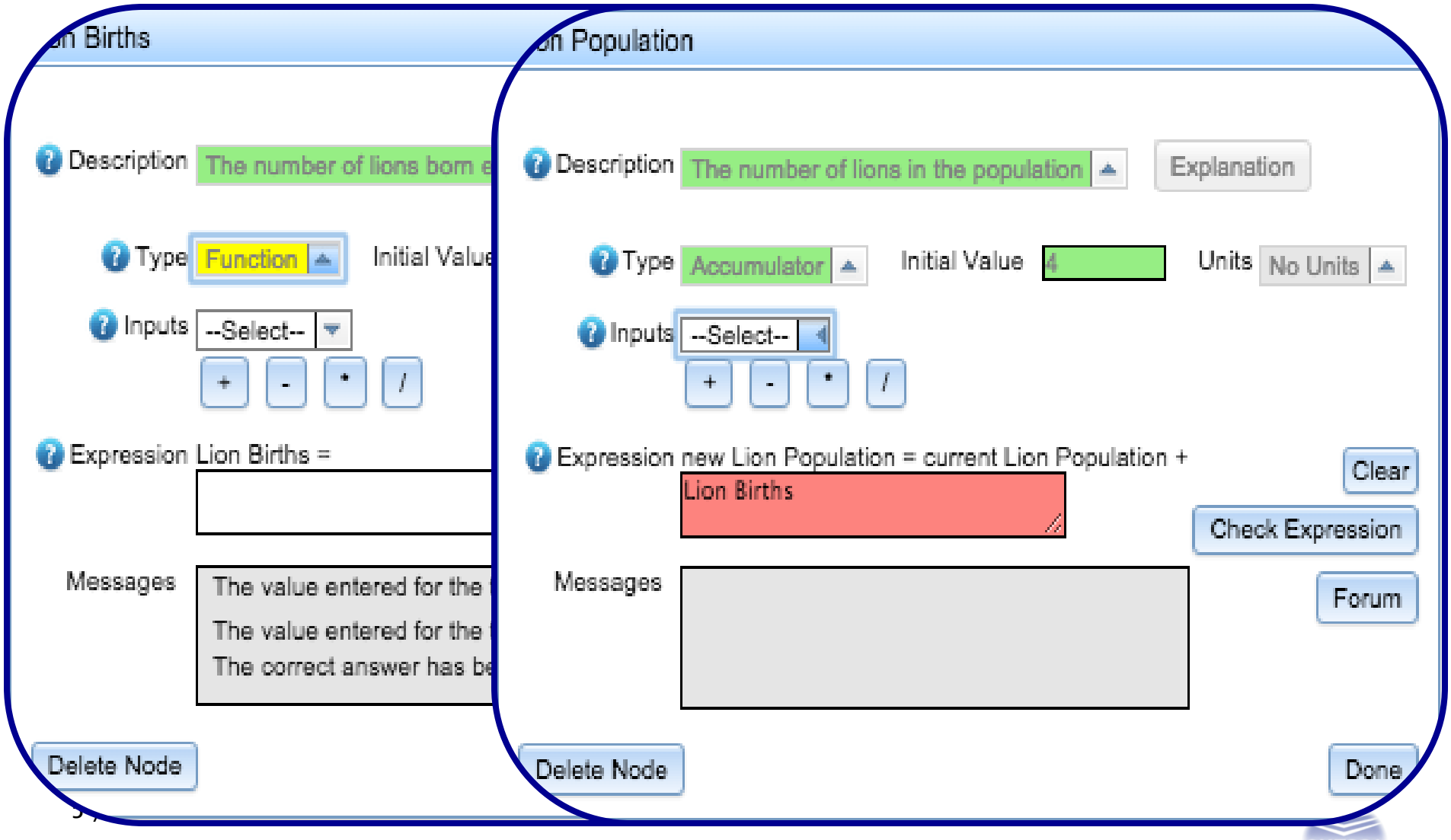
"Dragoon"

- Systems modeling intelligent tutoring tool
  - ✓ *Novel technologies necessary to build a comprehensive assessment and instruction system*
    - ❖ *Domain customization, automated interactive testing, and feedback*
  - ✓ *Helps students learn computer-based systems modeling and dynamics*
    - ❖ *Model construction, and by interacting with specific systems, concepts, and principles.*

“Dragoon” Authoring Mode

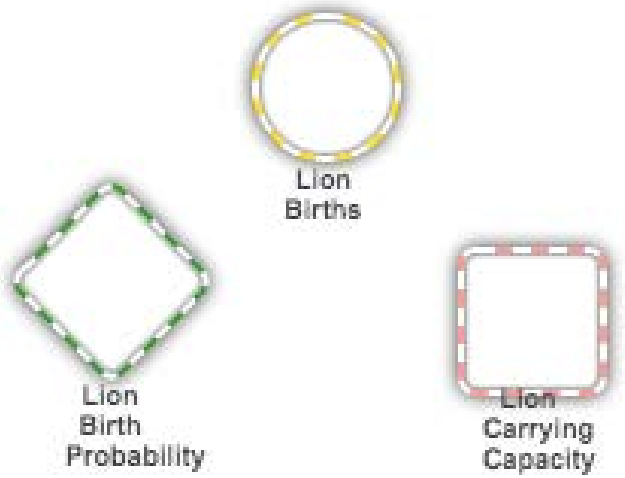


“Dragoon” Instruction, Assessment, and Feedback Mode



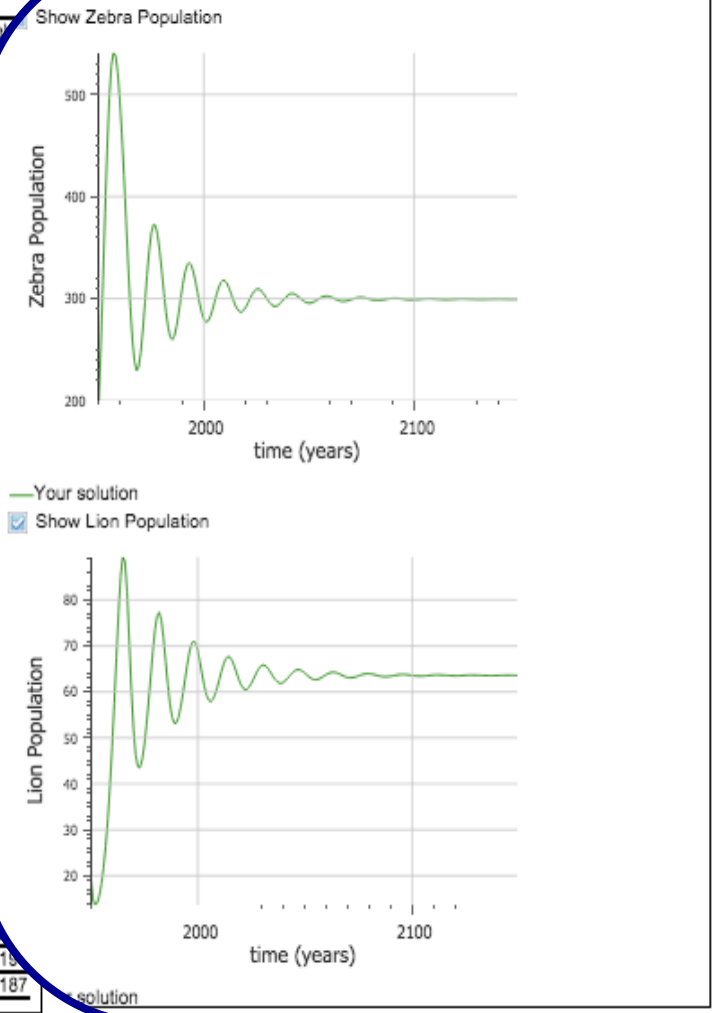
“Dragoon” Instruction, Assessment, and Feedback Mode

The models you made in Levels 1, 2 and 3 predicted that the lion population would increase indefinitely. Clearly, that won't happen because lions will starve to death where there are too many of them for the amount of grassland they occupy. Ecologists use "carrying capacity" to refer to the maximum population that can be supported by a given habitat. The model below assumes that the death probability rises as population increases until the death probability equals the birth probability when the population equals the carrying capacity.



“Dragoon” Instruction, Assessment, and Feedback Mode

time (years)	Zebra Population	Lion Population	Zebra Births	Predation Events	Zebras Killed	Ze... Sta... Pr...
1950	200	20.0	100	40.0	18.0	
1951	253	15.0	127	38.1	17.1	
1952	317	13.7	159	43.3	19.5	
1953	384	14.0	192	54.0	24.3	
1954	447	15.6	223	69.6	31.3	
1955	496	18.2	248	90.1	40.5	
1956	528	21.8	264	115	51.7	
1957	541	26.5	271	143	64.4	
1958	538	32.4	269	174	78.4	
1959	522	39.6	261	206	92.9	
1960	495	48.0	248	238	107	
1961	461	57.5	230	265	119	
1962	420	67.5	210	284	128	
1963	377	77.2	188	291	131	
1964	333	85.1	166	283	127	
1965	293	89.4	146	261	118	
1966	260	88.3	130	230	103	
1967	238	81.6	119	195	87.5	
1968	229	71.1	115	163	73.5	
1969	233	60.3	117	140	63.2	
1970	248	51.7	124	128	57.6	
1971	270	46.3	135	125	56.2	
1972	297	43.7	148	130	58.4	
1973	324	43.5	162	141	63.4	
1974	347	45.2	174	157	70.6	
1975	364	48.3	182	176	79.1	
1976	372	52.6	186	196	88.1	
1977	371	57.7	186	214	96.5	
1978	362	63.3	181	229	103	
1979	346	68.8	173	238	107	
1980	327	73.4	163	240	108	
1981	306	76.5	153	234	105	
1982	287	77.3	143	222	99.7	0.
1983	272	75.6	136	205	92.3	0.1
1984	262	71.7	131	188	84.6	0.187



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Zebra Birth Probability = 0.5

Probability of Zebras Killed = 0.45

Zebra Carrying Capacity = 700

Size of Range = 100

Lion Birth Probability = 0.5

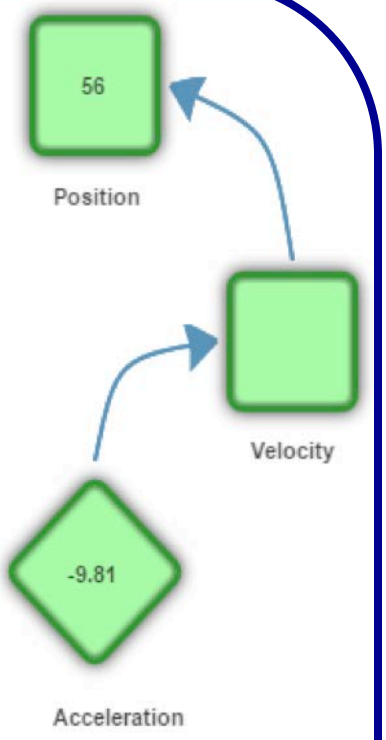
Lions Fed per Zebra Killed = 0.742

Initial Zebra Population = 200

Initial Lion Population = 20

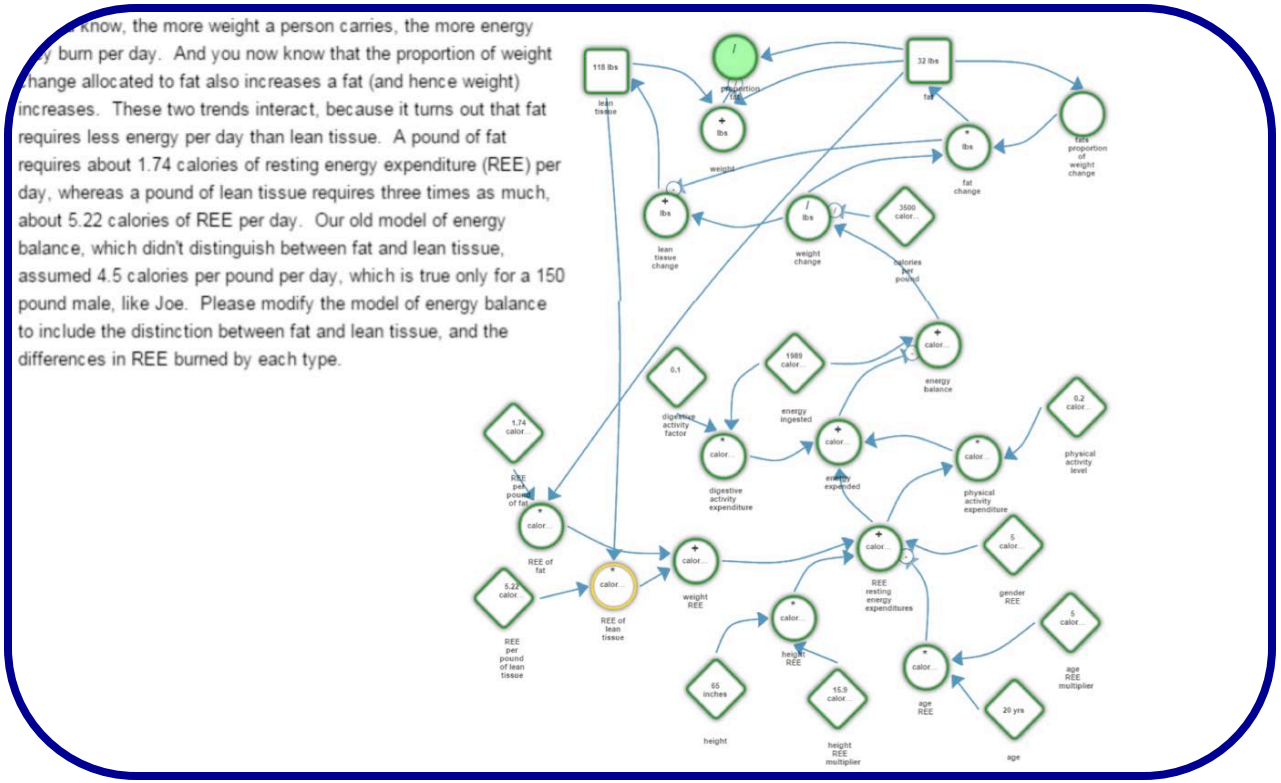
3 Studies: Overview

- Study 1: Physics
  - ✓ *Usability Test*
  - ✓ *AP Physics*



An object starts at rest and falls from a building that is 56 meters tall. Graph its velocity and position from 0 seconds to 4 seconds. Use 9.81 m/s^2 for the acceleration due to gravity. Choose coordinates so that the ground is at zero.

3 Studies: Overview



- Study 2
  - ✓ *Field Test*
  - ✓ *Purpose: compare Dragoon to baseline instruction over a longer period of instruction*
  - ✓ *Physiology (Energy Balance, Blood Glucose Homeostasis)*

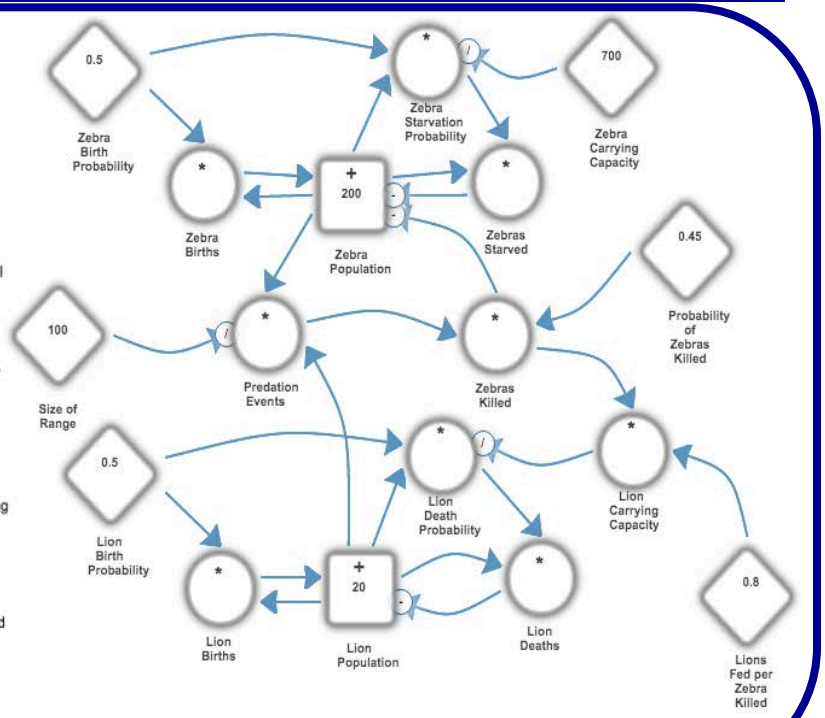
3 Studies: Overview

When zebras and lions live in the same area, their populations are linked by predation. The more animals, the more likely that they will run into each other, with fatal results for the zebras. However, the larger the area the animals range over, the less likely the animals are to run into each other. Let's assume that the number of predation events is the number of zebras times the number of lions, divided by the size of the range. Assuming there are initially 200 zebras and 20 lions, and the range is 100, the number of predation events during the first year is 200*20/100 = 40.

The number of predation events per year affects zebras because there is, let's assume, a 45% chance of a zebra being killed in during a predation event. If there are 40 predation events in the first year, then 18 zebras are killed.

The number of predation events also affects the lions. The more zebra's killed per year, the larger the number of lions that can be fed that year. Modify your model so that the carrying capacity is the number of lions that are fed by each zebra times the number of zebra killed. Assume each zebra feeds 0.8 lions.

's assume that predation does *not* affect the birth probability of .5), the birth probability of lions (0.5) and the deaths of



- Study 3
  - ✓ *Field Test*
  - ✓ *Replicate study 2 within a new domain and new context*
  - ✓ *AP Biology: Ecology (population dynamics)*

Study 2: Physiology Sample

- 95 total participants (Physiology students)
  - ✓ *45 treatment (Dragoon, 2 classes)*
  - ✓ *50 control (2 classes)*
- Majority 10th graders (72%)
  - ✓ *Most enrolled in geometry math class (60%)*
  - ✓ *Nearly all Dragoon and control students (95%) had never taken a programming class*
  - ✓ *No experience programming outside of school (97%)*

Study 2: Design and Procedure

- Content: physiology and systems modeling
- 5 day implementation window (55 minute class periods)
  - ✓ *Pre and posttest on first and last day*
    - ❖ *Consisted of 5 questions about energy balance and homeostasis*
    - ❖ *Short essays, mathematical derivations, interpretations, and concept mapping*
  - ✓ *Intervention day 2, 3, 4*
    - ❖ *Dragoon: teacher introduced systems modeling, researcher introduced Dragoon, students collaborated on Dragoon problems*
    - ❖ *Control: teacher introduced systems modeling, students collaborated on equivalent workbook problems*

Study 2: Results

- Pretest
  - ✓ *Mean score for Dragoon group was 1.69 (SD=1.58) out of a maximum score of 6.*
  - ✓ *Mean score for control students was 1.16 (SD=1.04); reliably lower (p<.01)*
- Posttest
  - ✓ *Mean score for Dragoon students was 4.53 (SD=1.71), out of a maximum score of 10*
  - ✓ *Mean score for control group was 3.59 (SD=1.52); significantly lower (p=.006)*

Study 2: Results Continued

- Pretest scores between the two groups were significantly different
- ANCOVA (pretest score as covariate)
  - ✓ *Dragoon group performed reliably better than the Control group (p=.029) with a medium effect size (d=0.47)*

Study 3: AP Biology Sample

- 59 total participants (AP Biology students)
  - ✓ *41 treatment (Dragoon, 2 classes)*
  - ✓ *18 control (1 class)*
- Majority 10th graders (58%)
  - ✓ *Remainder in 11th (35%) and 12th (7%) grade*
  - ✓ *Most enrolled in trig/pre-calculus (73%); remainder (27%) in calculus*
  - ✓ *Some of the students (34%) had taken programming classes*

Study 3: Design and Procedure

- Content: ecology; population growth, predator-prey relationships
- 6 day implementation window (100 minute class period – block schedule)
  - ✓ *Pre and posttest on first and last day (40 mins each)*
  - ✓ *Comparable forms covering 5 population dynamics question:*
    - ❖ *Open-ended, graph completion and analysis, graph interpretation, conceptual population growth, concept mapping*

Study 3: Design and Procedure Continued

- Intervention day 1, 2, 3
  - ✓ *Dragoon: researcher introduced systems modeling, researcher introduced Dragoon, students first worked individually, and later collaborated on Dragoon problems in pairs*
  - ✓ *Control: teacher introduced systems modeling, students first worked individually, and later collaborated on workbook problems in pairs*

Study 3: Results

- Average Inter-rater reliability .82 (Cronbach's alpha)
- Pre-test scores between two groups not statistically different
- ANCOVA (pre-test score as covariate)
  - ✓ *Dragoon group (M=31.00; SD=6.00) performed significantly better than the Control group (M=24.00; SD=6.96)*
  - ✓ *The difference was reliable(p=.029) with a large effect size (d=1.00)*

Additional Findings

- Students enjoyed working collaborative (dyads, groups) more than individually while working with Dragoon.
- Students liked the feedback; would have liked it to be even more explicit.
- Teachers and students agree that tool can be more intuitive.
- Teachers and students agree that they learn from Dragoon.

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