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Rubrics for Understanding

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Abstract

A group of K-12 educators have developed a set of rubrics for assessing the understanding generated by the use of system dynamic tools. These rubrics were used at the DynamiQUE*ST* exposition for grades 5-12 students in May of 2000. This is a presentation of the rubrics which includes standards for behavior over time graphs, causal loop diagrams, stock/flow maps and system dynamic models as well as an over-arching rubric for assessing the understanding generated by the use of these tools. Feedback from those who read the rubrics is sought to enhance efforts to bring standards to the use of system dynamics in K-12 education.

Introduction

DynamiQUE*ST* 2000 was a celebration of student work in the field of system dynamics designed to bring together students and teachers who are learning to think systematically and employing the tools and method of system dynamics to increase understanding. For six years there has been a fair of system dynamics projects by high school students in the Portland, Oregon area called SyM Bowl. This fair has highlighted the work of students who are taking system dynamics modeling classes.

A group of K-12 educators in the New England area wished to build on the extensive work and energy poured into the SyM Bowl by creating an exposition on the East Coast of the United States. There were a few significant characteristics, which the educators wished to capture in their event:

1. An emphasis on grades 5-12 (ages 11-18)
2. An atmosphere of encouragement and learning
3. Demonstrations of the system dynamics tools put in the context of the understanding they generate
4. A set of understandable standards for teachers and students to measure their work

One of the primary concentrations of the event was to give students appropriate and helpful feedback in order for their participation to be a learning experience. Instead of Judges, there were Coaches. It was a lot harder for the adults running the exposition to be consistent about the lack of the competitive process than it seemed to be for the students to accept and enjoy the freedom. There were no “prizes”. In order to enhance the learning, the group felt that the standards had to be clearly delineated. Although there has been some work done in this realm both by the SyM Bowl committee and individually by several school systems, no clear set of standards existed for such projects.

Students could enter original work or their application of other work (from the Creative Learning Exchange or CC-STADUS/SUSTAIN in Portland, etc.) This might include a unit, a lesson, or an application of one or more of the systems tools. The objective was to meet the standards that apply to the work submitted for DynamiQUE*ST*, whether it is a BOTG or an extensive project with a working model. The philosophy of DynamiQUE*ST* is to improve student learning by honoring the work of students as they learn the tools and method of SD/ST.

In order to set the standards, the group designed a set of rubrics for four system dynamics tools: behavior over time graphs, causal loop diagrams, stock/flow diagrams and system dynamics models. Over arching all of these is the Rubric for Understanding which delves into the understanding generated by the use of the SD tools. The rubrics were used by coaches to provide feedback related to students' use of systems tools and development of systems understanding. One of the major goals of presenting these Rubrics at this conference is to encourage you all to participate with us to make the Rubrics standards that can be used for any age learner.

RUBRICS FOR UNDERSTANDING: USING SYSTEM DYNAMICS TOOLS

Available at www.clexchange.org under the name of SE1999-11RubricsForSDTools

These rubrics were created to be used as a complete package. Use of any one of the Rubrics without the Rubric for Understanding does not further the powerful learning which can occur when system dynamics tools are utilized. Creating a system dynamics model, for instance, could necessitate the use of all of the other four Rubrics. If only a Behavior-Over-Time-Graph (BOTG) were being created, the BOTG Rubric and the Rubric for Understanding would be pertinent.

Created by
The DynamiQUE*ST* 2000 Committee*
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*** The DynamiQUE*ST* 2000 committee***:*
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RUBRIC FOR UNDERSTANDING
For use with all other Rubrics

CATEGORY	MEETS STANDARD	COMMENTS
DEFINITION OF THE QUESTION **Time horizon** **Boundaries of the system** **Key factors in the system**	❑ The question is clearly defined ❑ The question has a manageable focus (is not so broad as to defy description or analysis) ❑ The time over which the system operates is defined and appropriate. ❑ The limits of the system of interest are indicated and exogenous factors are differentiated from endogenous factors. ❑ The choice of key factors in the system is supported.	
DESCRIPTION OF MENTAL MODEL OF SYSTEM **Behavior** **Assumptions**	❑ A written description of the behavior of the system is included, with details about how the system behaves including major feedback loops and delays. ❑ Reference mode or hypothetical BOTG is evident for major stocks (levels) in the system. ❑ Assumptions or simplifications used to develop the mental model of system behavior are clearly described.	
PRESENTATION **Graphs, Pictures and Tables** **Easy to Understand Display**	❑ The presentation clearly describes the system and system behavior under study for the appropriate audience. ❑ Visual tools are used to support the presentation and analysis. ❑ The display is clear, neat, and aesthetically pleasing. ❑ All elements of the diagram are clearly and accurately labeled.	

REFLECTION **"What have you learned?"**	In this project the student has addressed the following questions: ❑ How has your original mental model been changed? ❑ Did anything surprise you? ❑ What part was the most difficult to do? ❑ Did your project answer your original question? If not, what have you learned from the process? ❑ Is anything still missing from your diagram or model? How could it be improved? ❑ How can you use what you have learned? ❑ Are there leverage points to change the system? ❑ What better questions can you ask now?	

RUBRIC FOR BEHAVIOR-OVER-TIME GRAPHS
For use with the Rubric for Understanding

CATEGORY	MEETS STANDARD	COMMENTS
VARIABLES: **"What is changing?"** **1. Horizontal Axis** **(Time)** **2. Vertical Axis** **(Behavior)**	❑ Horizontal axis represents time. ❑ Increments are clearly labeled and related to the behavior. Can be numeric or descriptive. (Ex. numbers of minutes; or "Beginning, Middle, End" of story) ❑ Scale encompasses enough time to show the complete pattern of behavior. ❑ Vertical axis represents key variable being studied. ❑ All variables are nouns. ❑ Increments are clearly labeled, reasonable, and related to the behavior. Can be numeric or descriptive. (Ex. Degrees Celsius, 1-100, or "Low, Medium, High")	
THE LINE: **"How is the variable changing?"**	❑ The graph is a continuous line graph. ❑ The line accurately depicts the behavior based on available data. ❑ The graph shows the pattern of behavior, focusing on the slope of the line and change over time rather than on only one event. ❑ If possible, the graph shows lines for more than one related variable.	
USEFULNESS	**See Rubric for Understanding.**	

RUBRIC FOR CAUSAL LOOP DIAGRAMS
For use with the Rubric for Understanding

CATEGORY	MEETS STANDARD	COMMENTS
VARIABLES (the words)	❑ All variables are nouns. ❑ All nouns used represent quantities worth measuring in terms of the causality which the loop is intended to explain.	
CONNECTIONS BETWEEN VARIABLES (+ / – and S /O)	❑ All +/- (s/o) relationships identified. ❑ Arrows connect related variables. ❑ Each arrow represents a causal relationship. ❑ Arrows show some kind of feedback. ❑ Connections are based on evidence or data or reasonable hypothesis. ❑ Delays are indicated.	
USEFULNESS	**See Rubric for Understanding.**	

RUBRIC FOR STOCK/FLOW DIAGRAMS
For use with the Rubric for Understanding

CATEGORY	MEETS STANDARD	COMMENTS
STOCKS (Accumulations)	❑ Stocks are nouns in the system which have quantitative values (absolute or relative) which can change over time. ❑ They are the central elements of the system. ❑ They are limited in number to allow insight into system behavior.	
FLOWS (Actions or processes that change the stock. They can flow into or out of a stock, or both)	❑ Flows are described with terms related to the same units as the stock they change.	
CONVERTER (Information, events or relationships which affect the rate of change of the flows if they are not constant)	❑ Converters are reasonably perceived to influence the flow. They are connected to flows by arrows which show influence.	
FEEDBACK (Circular connections showing influences within the system)	❑ Elements show circular causality (feedback) within the system. ❑ The diagram is easy to read, with a minimum of crossing lines.	
USEFULNESS	❑ The structure of the problem is evident from the diagram. ❑ Interdependencies and feedback give insight into what makes the system behave as it does. **See Rubric for Understanding.**	

RUBRIC FOR SYSTEM DYNAMICS MODELS
For use with all other Rubrics

CATEGORY	MEETS STANDARD	COMMENTS
CONCEPTUALIZATION	❑ The model has a clear purpose stated in behavioral terms. ❑ A behavior over time graph shows the behavior the model aims to explain (a sketch based on observation, reading, experience, etc.). ❑ Key elements of the system and their basic interrelationships are hypothesized. ❑ Boundaries are clear. ❑ The topic is appropriate and useful to model: it is dynamic (includes feedback) and a model would provide useful insight into the change. The cause of the behavior is endogenous.	
MODEL CONSTRUCTION **The Diagram**	**All Standards for Stock/Flow Diagrams apply.**	
The Equations **(The assumptions)**	❑ Equations describe causal relationships in math terms. ❑ All stocks are accumulations and their flows are in the same units per time. ❑ Units are listed for each equation and balance throughout the model. ❑ All equations are briefly documented in simple terms. ❑ Long or complex equations which cannot be explained simply are broken into simpler converters for clarity.	

Equations (cont'd)	❑ All variables represent real world entities; they can be "soft" or "hard." ❑ All parameters (constants) have reasonable, real world values. ❑ "Switches" are used sparingly. ❑ Graphic functions accurately capture complex non-linear relationships, Curves are smooth.	
Simulation Mechanics	❑ The solution interval (DT) is • 1/3 of the smallest time constant to produce a smooth curve. ❑ The length of simulation is chosen to show the complete pattern of behavior. ❑ Scales are appropriate for ease of interpretation.	
The Structure	❑ The model starts with a simple structure and builds in complexity. The simpler model is included if the model is complex. Sectors may also simplify a complex model.	
THE OUTPUT	❑ The model accurately captures the behavior, or an explanation tells what is missing and why. ❑ The graphs show the behavior under varying conditions. ❑ Supporting graphs show all other important variables in the model, their interrelationships. ❑ Tables may be used to explain specific points.	
USEFULNESS	**See Rubric for Understanding.**	