Effective Use of Simulations in the Classroom

by
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Foreword

This paper is the product of my early retirement program in Catalina Foothills School District. When I decided to retire after twenty-five years teaching middle school in the district, I met with the superintendent, David Ackerman, to discuss ideas for a project to fulfill my commitment of forty days work. He expressed the hope that I could do something to insure that my expertise in using classroom simulations could be captured in a form that would help future teachers continue the effective use of this teaching method. The ensuing partnership with the System Dynamics Project made this paper possible and probable. And as a result of this collaboration we were able to include computer assisted system dynamics simulations in the guide.

When I first encountered simulations as a teaching tool, they were called simulation games and as such had score-keeping, winners and losers. In those days competition in the classroom was not only tolerated but fostered; it was assumed that competition was the key ingredient to student enthusiasm for this teaching method. Typically an assignment would be made that involved learning certain material (objectives) in order to play the game. In fact, the student who successfully completed the assignment first not only earned the most points but was allowed to choose his part in the simulation game. This had the double purpose of being an incentive to students and assuring the teacher that the "smartest kids" would get the best parts. As the best parts usually held the probability of earning the most participation points, those students would continue to receive the highest grades. This appeared to be fair because it perpetuated the accepted system and insured that the learning activity ran smoothly because the most capable students were in charge.

After suffering through some devastating problems involving game scores and student grades as well as struggles with my conscience about fairness, I finally realized that the simulation could stand on its own without the game aspect, without a winner and the consequent losers. Every student could accomplish the objectives and, indeed, was expected to do so; collaboration could replace competition and good grades rewarded good learning and were not rationed. Hidden talents emerged as unlikely students excelled in starring roles and the simulations got better and better. This legitimized classroom simulations as a philosophically sound teaching method. Students played on a level field with many options available to accommodate individual differences. The simulations continued to be highly motivating and fun for an even higher percentage of students.

Toward the end of my career I found it difficult to teach without using a simulation although I occasionally did for a breather and to provide the students with a basis for comparing teaching methods. When Frank Draper introduced computer assisted system dynamics simulations in his science classes, we became interested in the possibility of designing simulations for social studies and science together. This paper, by discussing and comparing two types of simulations, may foster that development in the future.

(Martha) Jane Dunkel Chilcott

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Catalina Foothills School District
System Dynamics Project

Introduction

In Catalina Foothills School District simulations have been used successfully for many years to teach social studies content in a real world context: a mock trial can be used to teach students about the court system; a mock Congress provides a forum for learning how laws are made. A model United Nations helps students understand the difficulties of seeking world peace. More recently, highly motivating and innovative computer-assisted simulations were developed to enhance learning in the science curriculum. A mining simulation teaches not only geology but decision-making that takes into account environmental issues. Designing a Park Project parallels real world problems between protecting the environment and providing for growth. In both types of simulations students increase their understanding of how a real world system functions and become aware of how that system connects to other real life systems.

Classroom simulations motivate students by keeping them actively engaged in the learning process through requiring that problem solving and decision making skills be used to make the **simulation** run. As the simulation runs, it is modeling a **dynamic system** in which the learner is involved (plays a role).

Thus participation in simulations enables students to engage in **systems thinking** and enhances their understanding of systems as well as of social science and/or science concepts.

This paper provides information that will help teachers understand *what a simulation is* as well as *when and why to use one.* Two types of simulations, *system dynamics simulations* and *role-playing simulations* will be explained and related to each other. Detailed information will be provided to help teachers implement simulations in their classrooms. This includes: what to do *before the simulation*, scripts for *setting the stage* with students, a *definition of debriefing* , its impact on learning and examples of *debriefing questions.* The *Appendix* includes a *glossary* , a selected list of *simulations being used* in CFSD, an overview of the process for *designing* system dynamics and role-playing simulations, *sample documents* and a list of *resources***.**

What is a Simulation?

A classroom simulation is a method of teaching/learning or evaluating learning of curricular content that is based on an actual situation. The simulation, designed to replicate a real-life situation as closely as desired, has students assume roles as they analyze data, make decisions and solve the problems inherent in the situation. As the simulation proceeds, students respond to the changes within the situation by studying the consequences of their decisions and subsequent actions and predicting future problems/solutions. During the simulation students perform tasks that enable them to learn or have their learning evaluated.

A simulation includes time for reflection and processing which allows students to share their experiences, assess their learning and evaluate their assessments against the intended outcomes of the simulation. In addition to accomplishing the objectives of the simulation activity, students often become interested in the real world system on which it is based and what makes it work the way it does.

A simulation is an instructional strategy (teaching method) that can be used with appropriate learning material at any level from the primary grades through graduate studies. The complexity of a simulation should reflect the grade level and the sophistication of the material being taught or evaluated. There are published simulations available for purchase but many teachers prefer to create their own. A well-designed simulation simplifies a real world system while heightening awareness of the complexity of that system. Students can participate in the simplified system and learn how the real system operates without spending the days, weeks, or years it would take to undergo this experience in the real world.

Periodic discussions provide the opportunity for students to collect their individual experiences, discuss the general principles or ideas contained in the simulation and relate these ideas to the real world situation. It is important for teachers who use simulations to allow time during the simulation for this discussion. It is also important to have "debriefing" discussions during and after the simulation. The debriefing, which should be as well-planned as any lesson, provides closure for the activity and should focus on the learning outcomes for the simulation. Some suggestions on how to lead post-simulation discussion are provided in the *Introduction to Debriefing* section.

For purposes of clarity it is necessary to distinguish between "role-playing" and simulations. When role-playing, students act out a predetermined set of events with foreknowledge of the outcome of their characters' actions. The purpose is to acquaint them with the historical scenario and to develop an awareness of the factors influencing a decision made at that time. It also allows students to practice "walking in someone else's shoes" and can lead to meaningful discussions about events that occurred in the past. An example would be role-playing the decision to use the atomic bomb in World War II.

In a simulation, students' actions determine the outcome of the situation they are simulating. The situation being simulated has existed, exists or could exist in the real world but the simulation modifies it to fit the parameters of classroom teaching. Passing laws in a mock Congress is an example of a simulation.

Deciding to Use a Simulation

Using a simulation as a teaching/evaluating method can be considered whenever the curricular material can be learned or student learning of prerequisite material can be evaluated, through their participation in a mock real world situation in which their choice of actions determines the outcome of the situation.

Teaching through a simulation requires a time commitment and carefully orchestrated organizational scheme from the teacher. The role of the teacher includes designing or

adapting the simulation to fit the unique needs of a group of students, teaching content/skills necessary to participate in the simulation, observing student interactions, monitoring and adjusting the simulation as necessary, assessing student learning, evaluating the simulation as a learning experience, and presenting the learning activity with great excitement and enthusiasm. Materials must be created and copied; each day's activities should be scheduled. In addition the teacher needs to allow time throughout the simulation for discussion. Because the teacher must do much of the work prior to the simulation being run, teacher time during the simulation is available for observation and coaching which are excellent ways to assess student learning. Using a classroom simulation is a lot of work but the success of students in a well-designed, appropriate simulation is extremely rewarding for students and teachers.

The authentic nature of many simulations can be highly motivating. The teacher's enthusiasm can be contagious especially if the role-playing is presented to students as a wonderful opportunity to change their identities. Students are actively engaged in the learning process as they solve problems and make decisions as this is done in the adult world. Simulations provide a forum in which creative, divergent thinking is legitimized and valued. Because simulations are much more like the "real world" than many classroom methods, students do not stop learning when the class period is over. Their interest carries over into informal out-of-class discussions with other students and adults in which experiences and ideas are shared and evaluated. Enthusiasm bubbles and school attendance is high. Students become educational ambassadors as they continue their discussions at home. Students describe this kind of learning as authentic and not boring.

When simulations are used for assessment or evaluation of prior learning of the content necessary to successfully participate in the simulation, some students may not be successful due to deficiencies in their grasp of the prerequisite material. If the opportunities and encouragement are provided to go back and learn the material and try the simulation again, every student could eventually be successful. Other students will volunteer to assist in these extra simulations held after school or at lunch because it is fun.

After considering these factors, if you think your teaching/learning objectives can be accomplished through a classroom simulation, the following sections of this paper will examine types of simulations and offer assistance in their implementation in the classroom.

Types of Simulations

This paper distinguishes between two types of simulations, role-playing and system dynamics simulations. While both meet our definition of classroom simulations (p. 1), the difference is a matter of focus and the emphasis on using computer technology.

Role-playing simulations provide students an opportunity to learn through playing a role in a scaled-down real-life situation in which students assume real world roles as they solve problems and make decisions. The student can see and discuss the results of these actions within the parameters of the simulated situation. In terms of application to the real world, he can hypothesize the impact of his actions but cannot ever know the consequences that course of action would produce in the real world. Through his participation, however, the

student learns how the real world system operates and experiences the trade-offs involved in decision-making within that system.

The focus in a role-playing simulation is on "learning by doing"–students learning how decisions made and actions taken within the system they are simulating lead to both short term and long term consequences within that system. Although most of the curricular content will be learned throughout the simulation (including debriefing), some prerequisite learning about roles within the system may need to take place before the simulation begins. The appeal of this methodology lies in the student being able to assume the identity of the role he is playing and discard his school identity. This frees him from the limits to learning that may be inherent in his reputation. Tremendous excitement is generated by this transformation which is contagious among students running the simulation and within the school community.

Computers, while not essential, can be helpful tools for teachers and students as they participate in a role-playing simulation. The computers can be used to store and retrieve information, present information in multiple medias, and provide additional structure to the activity. Computers facilitate bookkeeping, speed up research and accelerate and compress time.

Because they are an effective and fun learning strategy, role-playing simulations are an educational technique that has been used successfully for many years. They can be purchased from a number of sources for teaching/evaluating a wide range of learning objectives. Teachers often adapt these to meet the unique needs of their class and curriculum; other teachers create original simulations. See *Appendix* for simulations suggested as instructional strategies in CFSD's social studies and science curricula.

System dynamics simulations are designed to help students experience a real-life situation as it plays out over time. The simulation is based upon a mathematical model of interrelated quantities that numerically describe the situation. Because the simulation is entirely based on elements that can be quantified as numbers, typically system dynamics simulations have a narrower scope than role-playing simulations. The actual enactment of a role in a system dynamics simulation is usually not as important as it is in role-playing simulations (although it can be made an integral part of the simulation).

A computer is an important part of a system dynamics simulation because it stores the underlying model holding information about the simulated situation. The model enables the computer to simulate, a step at a time, the real-world situation, based in part upon the student decisions. During each round of the simulation, the students make decisions and input these decisions into the computer. The computer uses the model to calculate new values for the other elements in the system. It then displays them to the student as numbers or graphs. Students make new decisions based upon this information, and the process repeats again.

Most of the work in preparing a system dynamics simulation is involved in building an appropriate computer model. Teachers can create their own system dynamics models independently, in collaboration with a **system dynamics mentor**, or use a model from one of the sources listed in the Appendix.

Use of System Dynamics Tools with Simulations

System dynamics is the study of systems and how they change over time. A system is defined as "a collection of parts which interact with each other to function as a whole." (Kaufman, Jr. p. 1) For example, an automobile is a system; a central heating system is another. "Systems can contain people as well as physical parts." (Forrester 1968) A person driving an automobile (steering the car as the road twists and turns) is a good example of this. Other examples of systems containing people are governments, economies, revolutions, and wars.

System dynamicists assert that cause and effect usually happen in a circle, called a **feedback loop.** A condition provides the basis for an action which changes the condition which causes a change in the next action. For example, if the temperature in a house is too cold the thermostat will turn on the furnace. The furnace raises the temperature until eventually the furnace shuts off. This self-regulating system is an example of a "balancing loop".

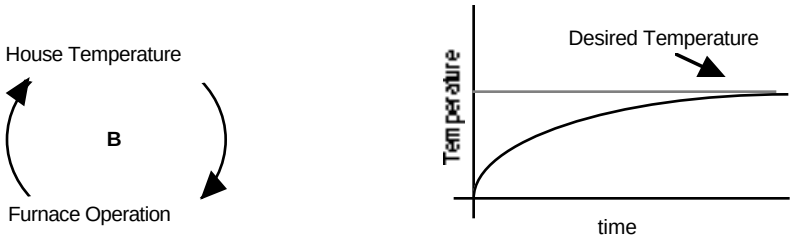


Figure 1: House Temperature

Another example: one theory of why the American Revolution began is that the colonists opposed the ruling British government because they felt oppressed. In response to the colonists' actions the government tried even harder to repress its rebellious citizens. This caused the opposition of the colonists to escalate, leading to war. This self-reinforcing growth pattern is typical of a "reinforcing loop".

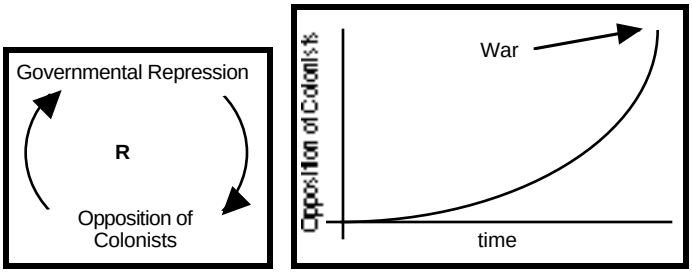


Figure 2: Revolutionary War

System dynamics provides six tools to help study systems and their behavior. One of these tools is the system dynamics simulation discussed in the previous section.

Two more tools, a **causal loop diagram** and **behavior-over-time-graph** are shown in Figures 1 and 2. Other system dynamics tools (all tools are defined in the glossary) are:

- **system archetypes**
- **stock-flow diagram**
- **system dynamics computer models** created with software such as STELLA II

Teaching students to use these tools appropriately enables them to become involved in systems thinking: conceptualizing, synthesizing and analyzing dynamic systems. More specifically, systems tools allow students to diagram their assumptions about the relationships in a system, to discuss and re-interpret those assumptions with other students, and to model and then simulate those assumptions, seeing their dynamic consequence.

The tools of system dynamics can greatly enhance either type of classroom simulation. It is natural to use them with system dynamics simulations as most elements of the simulation will already be numerically quantified. This quantification makes it easy to graph or indicate what causes the elements to increase or decrease. Because role-playing simulations are broad and difficult to quantify, students will need to focus on a particular section before designing an applicable graph, diagram, or model. With either type of simulation, the system dynamics tools may be used as part of the pre-simulation instruction, to do problem-solving during the simulation, or within the post-simulation debriefing.

One interesting aspect of using system dynamics tools is the awareness students develop of the poor decision-making and problem-solving that exist in the real world system they are studying. If it is so easy to figure out long term viable solutions and test their efficacy by tinkering with the system (running computer models) why aren't the people in power doing it? Many students will realize that merely responding to events creates short term solutions whereas making changes in the underlying relationships of the system is more apt to create long term solutions.

IMPLEMENTING SIMULATIONS IN THE CLASSROOM

Before the Simulation

While a lead-in to any learning activity is recommended, setting the stage (anticipatory set) for a simulation is especially important because this type of activity is sometimes interpreted as a "fun" activity rather than a learning activity. In addition to getting students excited about the simulation, they need to know exactly what they are expected to accomplish/learn through their participation.

Usually it is equally important to communicate the objectives to others in the school community as well as to parents of participants. Effective communication decreases the likelihood of misunderstanding and misinterpretation. Thus you are not only

communicating learning objectives but providing an opportunity for others to cooperate with and volunteer to help with, the logistics of an often complicated set-up. Through this communication process you can explain the use and value of a simulation as a learning activity. Invite constituents and colleagues to observe so they can see for themselves.

There are many ways of handling this communication and the teacher should choose those that are comfortable and most compatible with his/her teaching style. Suggestions include a letter to students and their parents, an article in the school newsletter, an informational packet for students to go over with their parents, class discussion, brainstorming, lecture with note-taking, etc. The following is a list of the points you should include in this orientation.

1. Specific learning outcomes.
2. Why a simulation is an appropriate teaching method for the content.
3. How to play a role effectively.
4. Reasons for differences between simulation and the real situation.
5. The importance of discussions and debriefing.
6. Keeping track of creative ideas, divergent thinking and unique observations.
7. The importance of and ways to uncover the dynamic system underlying the real world situation being simulated.
8. Learning how and when to use causal loops, behavior-over-time graphs, leverage points, stock-flow diagrams, computer models.
9. Classroom management: student responsibilities and teacher's role.
10. Evaluation of participation and learning including necessary record-keeping and official forms.
11. Student input to planning and improving classroom activities.

SETTING THE STAGE...direct presentation to students
The following is an example "script" of what a teacher may say to introduce a simulation.

> The next learning activity which we will be doing is a simulation which means you will play roles in a model of a real life situation. Our primary purpose is to learn certain content that is part of our curriculum. I have chosen a simulation as the method of learning this material for many reasons: I think you will enjoy learning in this way, you are likely to see the importance of what you are learning, and this content is easy to learn by "doing." Here is a list of the things you should learn during this activity; your questions and comments are very appropriate at this time.
>
> In order to make the simulation as realistic as possible it is important for us to play our roles as appropriately as we can, realizing that the people who are in these roles in the real situation are older, experienced in that job, often highly trained, and motivated to perform effectively by a multitude of pressures e.g. they could be fired! The real situation also requires a setting and equipment as well as a level of complexity that we cannot replicate. Let's identify some of the aspects

we cannot replicate. (Discussion). Therefore, we must think of our simulation as a simple model which does not contain all of the aspects of the real situation but from which the principles upon which the real situation operates can be learned.

It is important to our understanding that we occasionally take time out to discuss what is happening as we run the simulation. This can increase your awareness of the process as it unfolds which affords you more opportunities for participation and learning. It is also extremely important that you jot down unique ideas that you encounter in yourselves and others as the simulation runs, to share during the debriefing. There are no right and wrong answers to any of the problems you solve or decisions you make during the simulation. Your observations may uncover valuable information about the system you are simulating. Watch for opportunities to see behavior over time, determine probable cause and effect, experiment with leverage points for changing the system or behaviors within the system, create stock-flow diagrams or other models you might construct to reflect behaviors of the system, and look for how things really work as opposed to how they are supposed to work.
Each of you will initially experience different learning based on the frame of reference you bring to the simulation. Feel free to try out your solutions and decisions and please ask for help when you need it. I will try to keep interruptions at a minimum. While you are working I will be circulating throughout the classroom observing and talking with you. I will also be responsible for providing everything you need to run the simulation as well as keeping attendance and participation records. I am here to assist as needed. It is our joint responsibility to make this a valuable learning experience.

In your team packet you will find directions for rotating roles as well as copies of all of the official forms that will be used throughout the simulation. Extra forms are available in the rack on the wall. Note that all blue forms need to be submitted to me as part of your individual evaluation, and each team must submit one copy of every green form for your team evaluation. The notes I take when I confer with teams and individuals are also used to evaluate your participation and learning. Please spend the next few minutes looking through your packets and asking questions to clarify anything you do not understand. Suggestions for changes are appropriate at this time, as well as throughout the simulation and especially during the debriefing.

Do you feel comfortable with the task and expectations? I expect this activity to last for the next two weeks but I have allowed some extra time so that we can be flexible. As always, we will negotiate your grade at the conclusion of the activity. Try to be here everyday as absences play havoc with teamwork and success. If anyone has an extended absence during the simulation, we will arrange alternate learning activities.

SETTING THE STAGE II...another way of presenting information to students.

"Our next learning activity will be a simulation; what does that mean?" The students brainstorm what a simulation might be with the teacher asking appropriate questions to keep the discussion going until all salient points have been covered. Someone (teacher, student, parent/staff volunteer) will record all ideas which can then be ordered into categories and lists as needed for clarity and closure. In this procedure all student comments are valid and recorded and most students will participate because it is safe to do so.

"According to our curriculum and the materials I shared with you at the beginning of the term, what content do you think we will be learning (evaluating) in this simulation?" Once the content is correctly identified, elicit reasons why a simulation is an appropriate method for learning (evaluating) this content. Judicious questioning will bring forth the points with which you want them to be familiar.

"Think about the situation we will simulate. How do you think we will have to modify the setting and equipment to fit into the parameters of our classroom and schedule?" As this discussion takes place good suggestions for use of regular classroom furniture and resources will emerge and should be noted and employed. This gives the students real ownership of the simulation as opposed to participating in a teacher-designed activity. "What are some of the significant differences between the real world performer of a particular role and the student simulating that role?" The responses to this inquiry provide students will reasons why their performances and indeed, their simulation, will not be as complicated and sophisticated as the real one.

"When we engage in simulations as class learning (evaluation) projects, each member of our group needs to assume some specific responsibilities; let's suggest and assign those now." Proceed to brainstorm generic tasks such as note-taking, reading, preparation of forms, grading, setting up classroom, handing in work, homework, clean-up, etc. and make sure everyone is aware of who is doing what.

"Take a few minutes right now to look over the objectives and other materials in the packets I have given each team. Let's take a look at the forms I have used in the past and let's brainstorm changes you think will make them more useful." At this time project the forms on a data show or overhead projector. "Please bring up any questions or comments at this time so we can all benefit from your concerns or suggestions. The work we did today will be given to you tomorrow in written form to add to your materials. "

Note: the first example was teacher directed and teacher centered. This example uses the Socratic method of teaching/learning to accomplish the same goals. With some groups of students talking "with" rather than "at" them works much more effectively. Often their questions and comments cover the points you were going to bring up and you can add those that are missed. This process increases active learning and decreases teacher talk time.

DEBRIEFING SIMULATIONS...a generic guide to uncovering the dynamics of a system.

Introduction to debriefing

As students become caught up in a simulation there can be much more learning occurring than that for which the simulation was designed. It is important for them to have the opportunity to sort out and clarify their thinking. They need to release the emotional tension of playing a role and move back into becoming themselves again. Also, "If their experiences in the simulation are not examined sufficiently, they may see the simulation as an isolated experience rather than as an experience that provides significant insights into real systems." (Fishbanks) Students, with appropriate direction, can use system dynamics tools while debriefing simulations to uncover the dynamics underlying the real situation on which the simulation is based.

The precise strategy for your debriefing depends on your objectives. Discussion works very effectively in debriefing because students can not only try out their ideas with other students but can feed on the ideas of others to increase the depth and breadth of their own thinking. Teachers sometimes feel uncomfortable with this method because involvement varies and many students appear to be off task or not involved during a discussion while others become extremely active and involved. A teacher should feel free to use any discussion guidelines that work with his/her students as long as the free flow of ideas is not hindered nor any student denied the opportunity to share his/her thinking. Recounting of anything experienced during the simulation must be allowed and valued. At the same time the teacher can seek input from all students through judicious questioning.

Thoughts and ideas can be recorded in categories on the board as long as this does not have the effect of curtailing discussion. Standard brainstorming technique mandates that all responses are valid and should be recorded without judgment. Suggested categories might include: personal reactions, events, problems, intended learning outcomes, suggested improvements, dynamics underlying system, and comparison to real life situation. The teacher should provide some assistance and structure for analyzing the feedback generated by debriefing as is stated in the commercial simulation Fishbanks.

> "Whatever the goal, the debriefing generally proceeds through seven stages:
> - describe the problems and events that occurred
> - determine the extent to which those also occur in the real system
> - decide what factors in the simulation were responsible for those problems and events
> - determine the extent to which those factors are also present in the real system
> - design changes in the simulation that would avoid or solve the most serious problems
> - indicate corresponding changes that could be made in the real system
> - gain commitment from the players that they will seek to achieve the necessary changes in the real system."
>
> (Fishbanks)

SUGGESTED DEBRIEFING QUESTIONS BY CATEGORY

Personal Reactions

- What did you enjoy most about the simulation?
- How did you feel about playing your role?
- Why was (not) this a worthwhile activity in terms of learning? enjoyment?
- Why do you think the teacher had you work as members of groups in the simulation? What did you learn from this?
- What do you think some long term effects on you may be resulting from this experience?
- What emotions did you experience as you did the simulation?

Events

- What were the main events of the simulation?
- What decisions were you asked to make?
- What is the difference between long term and short term effects (consequences) of your decisions in the simulation?
- What do you predict they would be in the real situation?
- What kinds of trade-offs or compromises did you make during the simulation?
- What trade-offs do you think would be necessary in the real situation?

Problems

- What problems did you encounter in making decisions or as a result of your decisions?
- What caused those problems?
- Do the events, decisions and problems occur in the real situation?
- Are the causes of the problems similar in the real situation?
- Can you think of some ways to change the simulation to avoid those problems?
- Would those changes also work in the real situation?

Suggested Improvements

- How could the simulation be improved so that you and/or others learned more?
- What other simulations could we create to extend our learning in this area?
- What additional kinds of learning might occur if we ran the simulation for an extended period of time?
- Would this be worthwhile?
- In what ways is the computer a valuable tool to help you run this simulation?

Learning Outcomes

- What new learning took place for you during this simulation? (Consider what you learned about working together in a group, curricular objectives, the real world situation.)
- What things you already knew took on new meaning?
- In what aspect of the simulation did you learn the most? What did you learn?
- What kind of connections to things you already knew did the simulation open up?
- What is it about the simulation that caused this to take place?
- How would you explain the difference between acting in a play and playing a role in a simulation?

System Dynamics

- Why do you think the teacher used a simulation for this material?
- Once you have run a simulation, why isn't it possible for you to return and replicate the experience?
- Explain how the impact of your decisions during the simulation might not be evident until a future time.
- How do you think delay between actions taken and seeing the results of the actions affects decision-making in the real world?
- Explain how people could measure long range impact of decisions.
- How did using SD tools help you in your work?
- Where did you observe effects becoming causes? Explain.

Real World

- Describe this simulation's connections to (is it part of) a much larger situation.
- In what ways did your decisions during the simulation affect the whole situation? How did that make you feel?
- What are some decisions you made that have not been tried in the real world situation? Why do you think that is so?
- What leverage points did you locate; did intervention at those points accomplish what you wanted?

FOLLOWING FORMAL DEBRIEFING...how to increase understanding of System Dynamics

At this point you should have reached closure on the actual workings of the simulation and can extend learning through focus on the dynamics underlying not only the simulation but the real world situation on which it is based. Building on their responses in appropriate categories, help students use the tools of system dynamics to facilitate a deeper analysis and a more thorough synthesis.

They can isolate a particular behavior and construct a graph to show the changes in the behavior over time. The interaction of variables can be shown with causal loop diagrams indicating leverage points for change. Quantities that change over time can be modeled as stock-flow diagrams and STELLA models with the quantities as stocks and the policies the relationships that influence the flows.

Summary

The focus of this paper has been to encourage teachers to enhance their instructional methodology and their students' learning through the effective use of role-playing and system dynamics simulations. The skills students acquire and the thinking they do as they run simulations should lead to the development of citizens who will be more informed and able to take an active productive role in their world.

Designing a System Dynamics Simulation

This appendix gives an example of what steps a teacher might go through to design a system dynamics simulation. It also describes the "New Deal" simulation activity designed by CFHS teachers Joanne Groh and Peter Garbus with system dynamics mentor Will Glass-Husain for an American History unit on the Great Depression.

Steps in Designing a System Dynamics Simulation

In designing this type of simulation, there are four steps that need to be done.

1. Create a focus for the simulation consistent with district curriculum.
2. Design and build the computer model.
3. Choosing and programming (if necessary) the software that students will use.
4. Design the activity that "wraps around" the simulation.

These do not need to be followed in order. For example, building the model may suggest changes to the focus of the simulation. Also, while specific student handouts and lesson plans do not need to be created until near the beginning of the use of the activity, you will probably find yourself thinking about instructional issues throughout the entire design process.

New Deal Simulation:
Using System Dynamics to Study Decisions and their Consequences

The project began when a teacher approached the mentor saying she'd like to "create a simulation to let kids experience the Great Depression." The mentor and the teacher scheduled a day-long workshop to study system dynamics and see how it might be used as part of the teacher's unit on the Great Depression.

The two spent the first half of the workshop discussing both the teacher's curriculum and the tools of system dynamics. They drew behavior-over-time graphs and causal loops describing the role of government from the 1930's to the present day. They also looked at examples of other system dynamics simulations. They discussed the student outcomes for the unit and some of the activities she already had planned. Then they were ready to design their own simulation.

Deciding on a Focus

To find the focus, the teacher and mentor brainstormed answers to three generic questions that the mentor asked the teacher. These questions helped to define a set of stocks and flows that were used in the computer model the simulation was based on. (see the glossary for definitions of stocks and flows).

1. What situation should the students be dealing with? What roles could they play?
2. What are some of the conditions (stocks) building-up / declining over time that are present in this situation?
3. What repeated decisions could students be making in the simulation? (The decisions will influence the flows for the stocks).

The brainstorm session led us to the following idea:

1. Students would play the role of FDR during the Great Depression from 1932 to 1940.
2. Some key conditions of the simulation that students would be shown:
    - number of employed people
    - amount of federal debt
    - a "Popularity Index"
    - a "Misery Index" indicating the extent of homelessness, bread lines, shanty-towns, etc.
    - the GDP or other production index
3. Decisions students might make and enter into the computer:
    - how much to spend on welfare relief programs
    - how much to spend on federal job programs
    - what rate to tax people
    - whether to have a progressive or flat rate tax.

Building The Computer Model

Before the end of the workshop, the teacher and mentor laid out all the stocks with their associated flows. They then started looking at what decisions and stocks influenced the flows. For example, the tax rate decision changes the federal debt (through the flow of deficits.) The stock "Employed" will also affect the deficit. (The more people working, the more taxes they can pay, thereby decreasing the deficit.) While the model was not finished during the workshop, over the next few days the mentor and teacher went back and forth until they had a draft diagram (also referred to as a "map" of the system.) Part of the diagram is shown in the following figure.

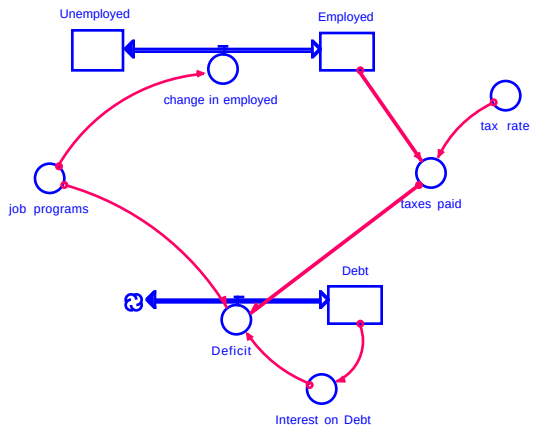


Figure 1: Partial stock-flow diagram for the New Deal simulation

At this point in the simulation design process usually the teacher and mentor would continue collaborating as they built the model. However, in this case the mentor went ahead and created the model on his own, as the teacher had no modeling experience. He then discussed each assumption in the model with both the teacher and an economist who had been working with the System Dynamics Project.

Choosing the Software

The software used in this project was STELLA II. Students can use the program in two modes: either directly examining the stock-flow relationships (such as the diagram shown in the above figure,) or at a level that hides these relationships while showing model output (via numbers and graphs) and allowing student input of decisions (via slide bars.) Due to the complicated nature of the model, the designers chose to use the second mode, hiding the relationships in the system. (see the figure below.)

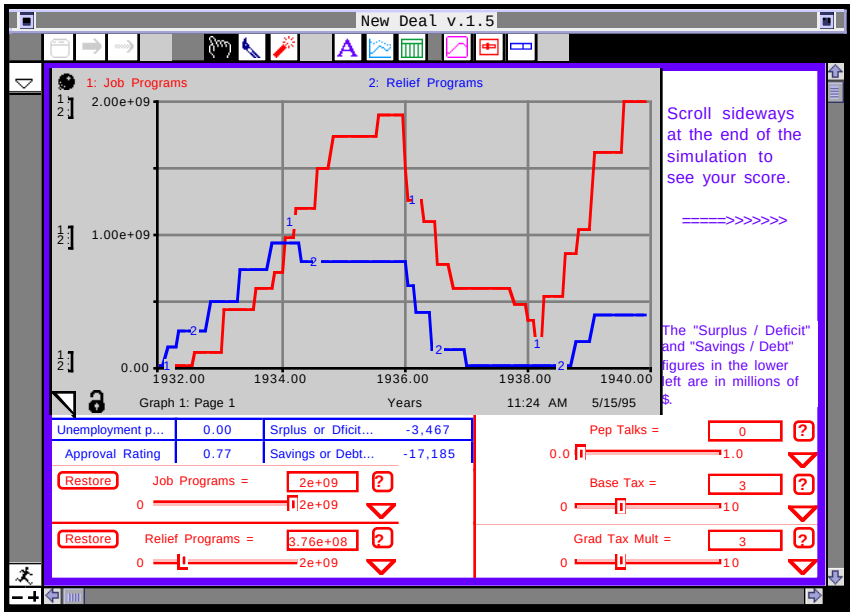


Figure 2: New Deal simulation

Designing the Activity

While the mentor and teacher had discussed activity issues since the first workshop, it wasn't until a few weeks before the activity was due to be used in the classroom that they began creating a detailed lesson plan. At this point another American History teacher was invited in, and the three people examined the simulation and discussed ideas.

The final plan was for the simulation to be used as part of an assessment of student learning throughout the unit on the Great Depression. From the beginning, the teacher had wanted students to use what they learned through their experience with the simulation as the basis for a set of recommendations on fiscal policy. To gain the experience needed for those recommendations, students ran the simulation multiple times, with a teacher-designated goal each time (experimenting with the simulation, following FDR's policies, or creating a final "best effort" simulation run.) The teacher then held an in-class debriefing (focusing on the economic relationships contained in the simulation, what FDR's actual policies were, and how modern day politicians might have run the simulation.) Finally, the students wrote a two page report giving a set of fiscal policy recommendations for the newly elected president of 1932.

Conclusion

This section tried to give you a sense of some of the steps to go through in order to design a system dynamics simulation. There are other ways of doing it, but this is a method that mentors in the System Dynamics Project have found to be successful.

An advantage of this method is that situations that are not conducive to a system dynamics simulation are usually discovered in the first step (choosing a focus.) The most common problem is that the situation is based upon a series of discrete events rather than a small number of stocks. For example, a planning session with counselors focusing on student behavior did not result in the production of a simulation. The expressed goal was to create a situation in which "students could make day to day decisions and see the long-term consequences of their actions." The workshops got bogged down in modeling this broad idea because many of the conditions and the decisions were either not quantified or were completely event-based. (Examples include parental attitude, teenage pregnancy, substance abuse and going to McDonald's instead of doing homework.) In this case the counselors' focus of the chosen situation was not specific enough or dynamic enough to allow them to build a system dynamics model.

Teachers interested in pursuing this type of simulation should contact their local system dynamics mentor (if they are in Catalina Foothills School District) or the Creative Learning Exchange (see the list of resources.)

Appendix

Simulation Checklist

Check off pre-simulation preparation activities as completed.

_____Select simulation; adapt as desired.

_____Identify objectives to be learned/evaluated through participation.

_____Develop procedures for evaluating/assessing student learning.

_____Design and print forms to use for teacher observation, evaluation.

_____Write scenario for simulation.

_____Identify roles students will play and describe in detail.

_____Plan daily schedule of simulation activities.

_____Share simulation plans with administrator and colleagues.

_____Write letter to parents.

_____Write article for newsletter.

_____Write letter to students.

_____Write outline for setting the stage with students.

_____Identify and reserve special space, equipment, schedule.

_____Design and print forms to be used in running simulation.

_____Prepare a parliamentary procedure outline for student-run meetings.

_____Prepare debriefing questions.

_____Design and prepare props to make simulation realistic.

_____Write outline for setting the stage with students.

_____Identify system dynamics applications in simulation.

_____Prepare alternate assignments for extended absences.

_____Prepare substitute plans for possible teacher absence.

Selected List of Simulations in Use at CFSD

High School:

Title	Type	Publisher	SDP Catalog #
Cell Flight Simulator	SD	CFSD SDP	K-1430
Exercise and O_2 Flow	SD	CFSD SDP	K-1432
New Deal	SD	CFSD SDP	K-1428
Public Health Clinic	SD, RP	CFSD SDP	K-1433
Soda Game a.k.a the Beer Game	SD	MIT	S-1417

Middle School:

Title	Type	Publisher	SDP Catalog #
Animal Farm	SD	CFSD SDP	
Blue River	RP	CFSD	
City-States	SD, RP	CFSD SDP	C-1064
Fish Banks	SD, RP	UNH	S-1299
Kaibab Plateau	SD	CFSD SDP	P-1089
Mining Simulation	SD, RP	CFSD	
Mock Congress	RP	CFSD	
Mock Trial	RP	CFSD	

Elementary:

Title	Type	Publisher	SDP Catalog #
Civil War	RP	Interact	
Colonization	RP	Interact	
Mini-Society	RP	Addison-Wesley	
Oregon Trail	RP	MECC	
Sante Fe Train	RP	Interact	
Stock Market	SD, RP	CFSD SDP	

SD = System Dynamics
RP = Role Play

Appendix

Designing or Adapting a Role-playing Simulation

This appendix gives an example of what steps a teacher might go through to design or adapt a simulation for the learning objectives he chooses to teach his students. It also describes the "Blue River" simulation adapted and used by Jane Chilcott to teach about local government in eighth grade social studies classes.

Steps in Designing a Simulation

1. Select learning objectives for students. (from district-approved curriculum)
2. Identify a real-world system through which those objectives could be taught.
3. Research available simulations that teach similar content.
4. Talk to other teachers who have used simulations to teach similar material.
5. Pull ideas (1,2,3,4 above) together and write a scenario for the simulation adapting it to the space, equipment and schedule available.
6. Identify and describe behavioral expectations for each role.
7. Determine how to measure learning and assign student grades.
8. Design forms and props necessary to run the simulation.
9. Write and distribute "Before the Simulation" communications (p.7).
10. Outline procedure for "Setting the Stage" (pp. 7-9).
11. Plan debriefing and system dynamics connections (pp. 10-12).
12. Share the planned learning activity with your administrator and colleagues before anything is set in stone. Be flexible and open to suggestions.

These do not need to be followed in order, but the first four steps usually precede steps 5 and 6. There is a built-in logic to the order but step 12 can occur earlier in the process. Specific student handouts and lesson plans do not need to be created until near the beginning of the use of the activity.

Blue River Simulation:
Incorporating Learning Objectives with a Real -World System

In teaching the levels of American government--local, state and national, local government always seemed to be slighted and viewed as less important and relatively uninteresting. Yet this is the level of government with which most people have the most contact. It is easy to relate this level of government to our daily lives. Could a form of local government based loosely on Pima County, Arizona, be set-up in the classroom to accomplish two major objectives: learn how local government operates and practice "effective citizen" behaviors? Furthermore, could this be the first activity of the year and if successful, continue to run throughout the year as the framework for a democratic classroom? (steps 1 & 2)

Research

Check sources through the library, catalogs of teaching materials, and the curriculum guide. Talk to other teachers who teach local government and pick their brains.

The **Interact** catalog had a simulation on local government, **Pressure**, which I ordered. After matching curricular objectives to some of those in the purchased simulation, I was able to use several of their ideas to develop a scenario and delineate and describe roles appropriate to my students, the curriculum and our local government.

Scenario

Each class section would represent a small community consisting of four neighborhoods, each of which would house approximately one-fourth of the heads of household. In other words, each household would be represented in the simulation by one adult played by a member of that class. The population would include citizens representing various jobs or professions, ages, a wide range of home ownership (tax valued) or rental housing, ethnic identities, educational levels, and strong interests leading to membership in various "pressure groups" in the community. Each of these identities would be described in detail on a small card, but adjustments could be made to better fit the demographics of each class as well as our community (Pima County). Some citizens held elected public office in the local government while others were appointed to various boards and commissions. All were members of one or more "pressure" groups.

Running the Simulation

The simulation action evolved around issues that arose from time to time which galvanized the community into action. I chose issues familiar and appropriate to our community: the building of a new school and school attendance boundaries; land development, use and rezoning; introduction of shopping malls and industry; traffic and transportation; and annexation, for example.

Each citizen would be expected to act and react to the issue depending upon his assigned identity's interest and the impact on his life. For example, public meetings would be held before the Board of Supervisors at which citizens would communicate their views. Those citizens who sat on various boards and commissions would have to act on the issue in that role as well as in accordance with personal interests. Elections would be held for public office which could also change board and commission membership and would include campaign speeches and support. Meetings of various community groups would be held to discuss an issue or life in "Blue River" in general. This small pseudo-community would function much like our community at the neighborhood level: members experience the multiple influences that converge on people of different economic and educational backgrounds as they function in their many roles.

The classroom set-up changed depending on what was happening in Blue River but generally students sat in their "houses" (a chair) in the neighborhoods (tables)

which were set up in the four corners of the classroom and greeted one another and visited as neighbors would when they came into class. Attendance was taken by neighborhood and an effort was made to develop a fairly strong neighborhood identity. (For many students this set-up was the most comfortable classroom situation they had ever been in as all students found themselves sitting next to and working with students outside their primary friendship group and everyone "belonged").

Discussions and debriefing would be planned at appropriate intervals following the guidelines in the paper (pp. 10-12).

Conclusion

This section provided an overview of steps appropriate to the design of a role-playing classroom simulation. A specific example illustrates how a teacher might implement such a design. The example, a simulation I called Blue River, was run for several successive years in various adaptations to fit the particular needs of that time. The students loved it and were very enthusiastic throughout, often begging to "go to Blue River" again. It was also successful in accomplishing the teaching/learning objectives. Because the planning starts with the objectives and locates a fit with a real world situation that can be used to accomplish them, these simulations rarely fail to educate students through an engaging experience.

Appendix

Sample of Student Orientation Letter

To: Eighth Grade Social Studies Students
From: Jane Chilcott
Re: "Going to Blue River"

During the next few weeks we will study local government through a simulation I call Blue River. This letter informs you of what that entails. Please read it carefully and mark those places where you have a question or comment. We will discuss them in class tomorrow.

You will be accomplishing the following learning objectives from our curriculum:

1. Learn the organization and processes of our local government.
2. Become familiar with local problems and the procedures for identifying and solving them.
3. Reach out into the community to provide a needed service.
4. Develop research skills.
5. Develop skills in using persuasion and compromise to achieve goals.

You will be expected to play a role in the simulation as follows:

Each member of the class will assume the role of an adult citizen of the community, which automatically includes membership in several community groups. You will be given an ID tag designating personal history, real property status, quadrant address, pressure group affiliation and local government position, if any. You play your role effectively by assuming the multiple identities and behaving consistently with your assumed personal history. You can develop your citizen responsibility role as fully as you desire through research and participation in discussions at meetings.

Our classroom will be set up into either the four neighborhoods of Blue River or the site of a public meeting, depending on the activities planned for the day.

The major difference between the simulation and the real situation is one of numbers. We will work with the number of students in the class as comprising the entire community, realizing that each of you will actually represent thousands of citizens in the real world. The physical set-up is likewise simplified by using chairs as homes, set around tables in the classroom which is divided into four neighborhoods (quadrants) representing the community of Blue River. When we have a public meeting (County Board of Supervisors, for example) the classroom furniture will be arranged to be similar to a meeting room. We will compress time in order to achieve results much more quickly than would happen in the real world where some decisions are debated for months before votes are taken. We

plan to focus on problems that are similar to actual problems that are facing our community but the problems will be simplified as needed to make them manageable for you.

We will use teacher evaluation (observation, class discussion and dialog), group evaluation (from each group with which you work) and self-evaluation as the basis for your grade in this unit. Playing your role appropriately, working effectively in a group, using research to develop and support your arguments, and making quality presentations will be important factors in your assessment.

Personal identities will be distributed randomly as you enter the classroom next Monday. The neighborhoods are set up carefully to help the simulation run smoothly, so please do not make any changes on your ID card without consulting me; trading cards is not recommended. You will sit in your house (chair) in the appropriate geographical location as marked on your ID card. You will then meet in your neighborhood groups so you can all “meet” your neighbors.

There will be several color-coded forms which we will discuss and develop together during class tomorrow that you will use during your work in this simulation. I am excited about going to Blue River and hope that you are, too.

See you tomorrow!

Appendix

Sample of Newsletter Article

During this school year, Mrs Chilcott's eighth grade students will "travel to Blue River," a mock community somewhere in Arizona. While running the Blue River simulation students will learn about local government.

"This simulation's purpose is to get students to directly experience–and to learn well– the exciting, vital processes of local government. During the simulation students will learn how to use the mechanics of local government for decision making; where the typical centers of power lie in most American communities, what the typical special interest groups are in most communities and how they operate."

(Pressure, a simulation by Interact Co.)

Students will experience the conflicts faced by citizens in a community in which they must choose between the good of the community and private gain or between economic gain and cultural gain. These student-citizens will come to understand how decisions made by their local government agencies regularly affect their lives. They will be faced with crises and will meet with their neighborhood groups as well as other "pressure groups" to which they belong. Some will also have to balance the role of elected official or appointed board member with that of parent, citizen, member of a pressure group, and wage earner.

"Trips" to Blue River will occur almost everyday during regular social studies classes. Parents, staff, and other members of the school community are welcome to join us as observers.

Appendix

Sample Letter to Parents

Dear _____,

During the next several weeks your student and his/her classmates will be participating in a simulation in social studies class that will help them learn about the components and workings of local government. Each member of the class will assume the role of an adult citizen of the community, Blue River, which automatically includes membership in several community groups. At the outset of the simulation each student will receive an ID tag designating personal history, real property status, quadrant address, pressure group affiliation and local government position, if any. The student plays his role effectively by assuming the multiple identities and behaving consistently with his assigned personal history. He can develop his citizen responsibility role as fully as he desires through research and participation in discussions at meetings.

Our simulation is designed to enable students to accomplish the following curricular learning objectives:

1. Learn the organization and processes of our local government.
2. Become familiar with local problems and the procedures for identifying and solving them.
3. Reach out into the community to provide a needed service.
4. Develop research skills.
5. Develop skills in using persuasion and compromise to achieve goals.

Each student will be evaluated/graded on his/her participation which includes appropriate role-playing, evidence of research in presentations, performance in speeches and/or running meetings, and cooperation in group work.

You are invited to join us in Blue River as an observer in any class. Check with your student to find out what is on the schedule that day.

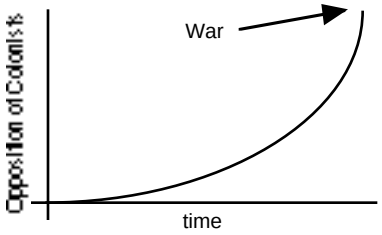
Sincerely,

Jane Chilcott
Social Studies Teacher

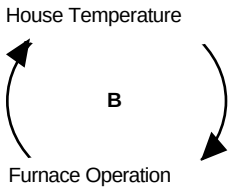
Note: Sometimes I have students fill in the greeting and add a personal note at the bottom of this letter. I give them their letter at the same time. The next day I do the “Setting the Stage” activity in class.

Glossary of Important Terms

behavior-over-time-graph (BOTG) — A system dynamics tool that is used to show how an amount of something changes over time. This amount may be something physical such as money or abstract such as happiness. The amount being graphed is shown on the vertical axis. Time is shown on the horizontal axis.



balancing loop — a balancing loop occurs when an action causes change that counteracts that action, balancing out the system. For example, in a cold house a thermostat will turn on the furnace, causing the temperature to rise, causing the furnace to turn off. A balancing loop is often shown as a causal loop diagram with a "B" in the center.



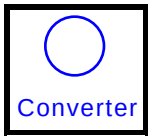
Catalina Foothills School District (CFSD) — a K-12 public school district with approximately 3,000 students in northwest Tucson, Arizona.

causal loop diagram (CLD) — a system dynamics tool that is used to show interrelationships between items. Specifically, each arrow shows how one item causes another item to change. An "s" by the arrow indicates that if the first item changes, the other item changes in the same direction. An "o" by the arrow indicates that if the first item changes, the other item changes in the opposite direction. The center of the circle usually has either an "R" (indicating a Reinforcing feedback loop) or a "B" (indicating a Balancing feedback loop).

coaching — a way of working with students in which the teacher makes suggestions and provides resources but does not provide direct instruction.

connector — a component of stock-flow diagrams and STELLA models. A connector shows how one element of a model influences another. A connector never points to a stock (only flows can change stocks).

converter — a component of stock-flow diagrams and STELLA models. A converter converts a value from one set of units to another. It performs instantaneous calculations. For example, density might be a converter calculated from a stock of volume and a stock of mass. Converters can also hold constants, such as the average lifetime of a person.



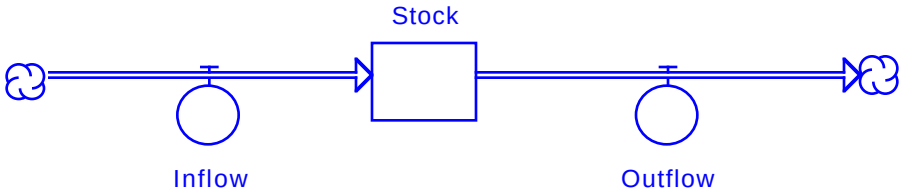
debriefing — a discussion in which students leave their simulation roles as they examine, discuss and analyze simulation experiences.

dynamics — a pattern of change or growth over time.

dynamic system — a collection of interrelated elements that change over time.

feedback — a process that occurs when people or objects in a system take actions based on the results of previous actions. Feedback can either be reinforcing (also called positive feedback) or balancing (also called negative feedback).

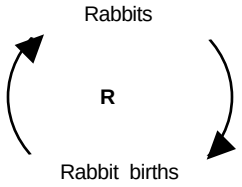
flow — a component of stock-flow diagrams and STELLA models. A flow represents the action or process that is the direct cause of change in a stock. Consequently, flows are often verbs. A flow is measured in the units of the stock over time. Flows for a stock of population might be “births” and “deaths”. Flows for a stock of heat might be “heat production” and “heat loss”. Flows for a stock of happiness might be “increase in happiness” and “decrease in happiness.”



map — a pictorial representation of a system, usually with a causal loop or stock-flow diagram.

model — a representation of a system. This can either be a "mental model" (the "picture" of a system people carry around in their heads) or a mathematical model of quantities and relationships. Mathematical models can be simulated with a software program such as STELLA II.

reinforcing loops — a reinforcing loop occurs when an action causes change that causes an acceleration of the action, reinforcing the effect of the original action. For example, rabbits give birth to more rabbits, who give birth to even more rabbits. A reinforcing loop is often shown as a causal loop diagram with an "R" in the center.

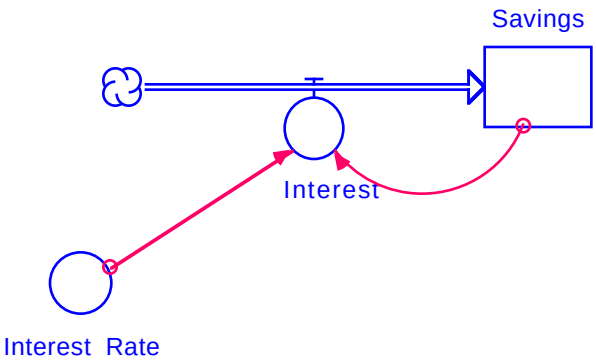


role-playing simulation — a teaching methodology involving a scaled down real-life situation in which students assume roles as they make decisions and solve problems in the real-life situation.

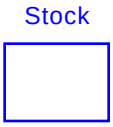
running a simulation — the process of playing out a simulation over time, specifically, letting students make decisions and see the consequences of those decisions.

simulation — a method of teaching/learning based on a scaled-down real-world situation. Two types of simulations are role-playing simulations and system dynamics simulations.

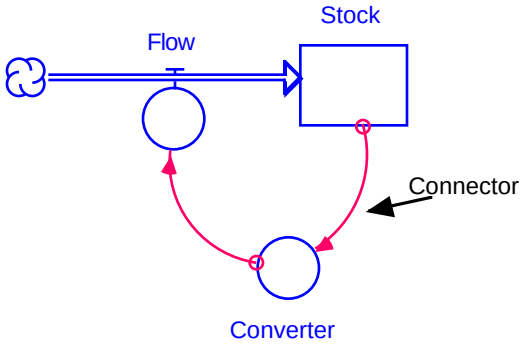
STELLA model — a model created with the software STELLA II (Systems Thinking Experiential Learning Laboratory with Animation.) A STELLA model represents a system both visually (with stocks, flows, converters and connectors) and with specific mathematical relation-ships. A STELLA model can be simulated, causing elements of the model to change over time. The output of the simulation can be repre-sented as numbers or graphs. A STELLA model can be used as part of a system dynamics simulation, or can be used independently to study a system.



stock — a component of stock-flow diagrams and STELLA models. A stock is an element of a system that is accumulating or draining over time (similar to a bathtub full of water.) Stocks cannot change instantly– they are the memory of a system. Flows are the only model elements that can change a stock–in a stock-flow diagram or STELLA model, nothing points to a stock except a flow. Population, happiness, money saved are all stocks. Births, monthly profit, and temperature are not stocks because they involve a process, not an accumulating quantity (births, profit) or they are directly based upon other quantities (temperature is really a measure of heat, which is a stock.)



stock-flow diagram — A visual representation of the relationships among the elements in a system using stocks, flows, converters, and connectors. Stock-flow diagrams are typically more specific than a causal loop diagram or a system archtype.



system — a collection of elements and inter-relationships. Systems often contain circular patterns of cause and effect called feedback loops.

system archetype — a system dynamics tool that shows a pattern of relationships that is

common to many systems. Generally speaking, these similar relationships produce similar change over time. System archetypes are usually drawn with causal loop diagrams, although there is a similar concept for stock-flow diagrams called generic structure.

system dynamics — a field that uses tools for the purpose of understanding feedback, complexity, interdependence, and the process of change. At CFSD, we use several system dynamics tools to look at systems: behavior-over-time-graphs; causal loop diagrams; system archetypes; stock-flow diagrams; STELLA models; and system dynamics simulations.

system dynamics simulation — a simulation based on a mathematical model of inter-related quantities. Because the simulation is based entirely on elements that can be quantified as numbers, system dynamics simulations typically have a narrower scope than role-playing simulations. Students using a system dynamics simulation are presented with numbers (shown in a table or graph) representing the system being simulated. They then make decisions and input those decisions into the computer, which calculates how those decisions affect the system. If the simulation is based on a STELLA model, the numbers seen by the students are the values of the stocks, while the decisions made by students are used to calculate the flows.

system dynamics mentor — a staff member of CFSD's System Dynamics Project who helps staff and students to use system dynamics.

Resources on Simulations and System Dynamics

District Resources

CFSD System Dynamics Project
1191 E. Orange Grove Road
Tucson, AZ 85718
(520) 575-1243
The purpose of the System Dynamics Project (SDP) of the Catalina Foothills School District is to facilitate use of the tools of system dynamics in classrooms. The project employs mentors to work with teachers who are interested in using these tools in their curriculum areas.

To contact an elementary, middle school, high school or at-large mentor, please call Joan Yates, Project Manager, at the telephone number above.

The SDP also maintains a library of systems articles, books, videos and simulations. Contact your SDP mentor or Mary Ann Baridon at 575-1243 for more information.

Out-of-District Resources

Creative Learning Exchange
1 Keefe Rd.
Acton, MA 01720
Attention: Lees Stuntz
(508) 287-0070
The Creative Learning Exchange (CLE) is an organization that helps teachers interested in system dynamics share information and ideas. They have a library of articles and example models that are available either for no charge or for copying/ distribution costs. Many of the simulations developed in the CFSD System Dynamics Project are on file with the CLE. They also have a free quarterly newsletter. (see the section "Selected List of Simulations Used in CFSD").

Interact
Box 262
Lakeside, CA 92040
Interact is a commercial publishing company that provides many of the role-playing simulations in use at CFSD. (see the section "Selected List of Simulations Used in CFSD").

MIT System Dynamics Group
MIT, E60-383
Cambridge, MA 02139
Attention: Nan Lux
The MIT group has a list of articles on system dynamics available for copying and mailing costs, including instructions for the MIT Beer Game. (see the section "Selected List of Simulations Used in CFSD").

University of New Hampshire
Institute for Social Science Policy Research
Durham, NH 03824
Attention: Karen Burnett-Kurie
(603) 862–2186
Contact the IPSSR for information on ordering Fish Banks, a role-playing system dynamics simulation. (see the section "Selected List of Simulations Used in CFSD").

System dynamics internet mailing list
k-12sd@sysdyn.mit.edu
This national electronic discussion group is for educators interested in using system dynamics. To subscribe, send an email note to Nan Lux (nlux@mit.edu).

Internet World Wide Web page on system dynamics
http://sysdyn.mit.edu
This page is maintained by the MIT System Dynamics in Education Project and can be viewed with a web browser such as Mosaic or Netscape.

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File Numbers beginning with "D" (e.g. D-4238) refer to the filing system of the MIT System Dynamics Group. File Numbers beginning with other letters (e.g. P-1212) refer to the filing system of the CFSD System Dynamics Project Library.

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