Supply Demand World (SDW): An Interactive Learning Environment for Teaching Microeconomics

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Abstract

Economy is dynamic and changing. One of the biggest problems with the introductory economics courses is that they are too static. System Dynamics can help us in teaching dynamic aspects of economy. "Supply Demand World" (SDW) is an Interactive Learning Environment (ILE) to teach introductory microeconomics based on the system thinking and system dynamics concepts. The paper presents the underlying system dynamics models used in the software as the base of the games and other teaching materials. It also introduces the teaching structure used in the software based on the learning theories discussed in the paper. Furthermore, the paper presents many unique features of the software and discusses how these features supports learners in developing a better understanding of the subject. An experiment conducted in a high school, to measure the teaching effectiveness of the software, shows that students worked with the software achieved much better results compared to the students did not work with the software in a similar test. The test was designed to measure students' understanding of the basic system thinking, system dynamics and economics concepts.

1. Introduction

In the late 1970s the word "microworld", used by an educator/artificial intelligence researcher Seymour Papert to define a computer based learning environment for children[1]. Today, it is used for any simulation which people can learn from it or as Peter Senge (2000) said, can live in the simulation and build a better mental model of the real world represented by the simulation. Microworlds are also called "management flight simulators", "business simulators", "management simulators" or "learning environments". A good distinction between "management flight simulators" and "Interactive Learning Environments (ILE)" has been introduced by Sawicka (2005). "Management flight Simulators" are those simulators supposed to use for facilitated learning and ILEs are those supposed to support individual learning. In this context "Management Flight Simulators" usually are used in workshop settings under the supervision of a facilitator. But ILEs usually are stand-alone System Dynamics (SD) Based simulators for individual learners (Sawicka 2005). Here, by the use of the term ILE, we mean stand-alone software which is designed for individual learners to build and improve their mental models about the real world represented in the software by the means of different teaching strategies like building dynamic models, analyzing the results of simulations, testing strategies, answering questions, and watching films and animations.

Although there are not enough evidences to prove the teaching effectiveness of the SD based Interactive Learning Environments (ILE) and business simulators but it seems that *they are promising tools for teaching and psychological research* (1990 Andersen, Chung, Richardson, and Stewart). *Using computer simulations to promote learning is a complex and challenging endeavor, with many possibilities for short lived gains and superficial advances* (Senge 2000). Currently, there are lots of "Management Flight Simulators" and ILEs to help people build a better understanding of the dynamics of the structures around them to take more intelligent decisions. Using system dynamics based ILEs in the context of economics is a recent and emerging idea.

Walstad and Allgood (1999) demonstrated with some experiments that the value added by economic courses is *minimal*. The most problem with the economics courses is that they are too static. Students learn that to find the new equilibrium of supply and demand, they must intersect two lines and the intersection point will indicate the new equilibrium point. But there is no or very little discussion about how everything changes to reach this new point, and also why all of the changes happen. In more sophisticated models, students totally lose the structure behind and they only learn how to solve problems by using mathematics, algebra and graphical comparative statics. Cohn et al. (2001) indicated that there is no significant differences in learning gain by students who received traditional instructions (graphical comparative statics) on a Keynesian concept, compared to whom received only verbal instruction. "*Comparative* *statics fails the usefulness test if its purpose is to explain the behavior of an economy during a transition from one equilibrium condition (or stable growth path) to another*" (Wheat 2004). But beside this, there is another important point lost in traditional methods of teaching economics concepts and that is the dynamic nature of economies.

Economy is dynamic and changing. Changes in the status of an economy are the results of interaction between different elements that constitute a system. To understand the behavior of an economy one should understand the interaction between elements that constitute the structure of a related system responsible for the behavior of interest. Then the causes of change in economic conditions should be explained in terms of system structure. The mental model of students for understanding economic phenomena should be shaped and strengthened based on such systemic structure and dynamic analysis. But traditional teaching of economics tends to train students for static and comparative static analysis of economy that mainly rest on equilibrium conditions. Such teaching lacks a holistic and systemic view of the world. Therefore, most of students who take economics courses can not seelack the whole picture. For example they know that how price changes can change demand and supply and also how supply/demand ratio changes can change the price but many of them can not discuss how all these relationships can work together. This problem does not limit to students. There are many evidences (at least in our country) that many decision makers who have taken their training through the traditional teaching lack the systemic view of the dynamic world. We believe that system dynamics is a suitable framework for teaching economics and its dynamics. For this reason we have developed an ILE which captures the fundamental concepts of supply demand sector based on a systemic view. It took about one year to survey on many interactive teaching methods, designing the appropriate method and providing the content and about another one year for programming and developing the software and measuring the effectiveness of the software. By developing this software, we pursue three main objectives:

1- Teaching supply/demand interaction concepts and dynamics.
2- Introducing system dynamics to learners
3- Increasing the degree of system thinking of learners

2. Fundamental Objectives

"Every learning environment should have some specific learning objectives. In the first step the objectives of the learning environment should be identified. The learning environment should be designed to fulfill its objectives" (Mashayekhi, 1996).

Learning objectives of ILEs can be classified into two groups (Mashayekhi 1996):

- ➢ Context objectives
- ➢ System Thinking objectives

With regard to this general classification, we have arranged our goals in the following manner:

- Context Objectives: Based on supply-demand interaction concepts we have settled these main context objectives to teach:
  - Relationship between supply, demand and price
  - Equilibrium and equilibrium price
  - Cost, revenue and profit concepts
  - Profit concept and profit optimization
  - “Supply capacity” and “orders backlog” concepts and effects
  - Price oscillations and over capacity
  - Price control and black market
  - Inventory role and hoarding

- System Thinking and System Dynamics Objectives: The ILE will also provide the opportunity of learning some elements of system thinking and system dynamics including:
  - System Perspective
    - System as interrelated elements to achieve a goal
    - System boundary
  - Thinking over time and relationship between changes of different quantities
  - Causal Relationship and causal loops
    - Cause and effect is underlying element of each change.
    - Cause and effects are positive and negative
    - Causal loops are a closed chain of cause and effects
  - Feedback concept and simple feedback structures
    - Growth
    - Goal seeking behavior
    - Overshoot and undershoot
    - Oscillation and escalation
  - Stocks and flows
    - There are accumulation of people, money, material,... in each system.
    - Accumulation takes place in stocks.
    - Each stock is increased and depleted by flows.
    - Stocks are the sources of delays.
  - Structure and behavior
    - Partial structure behavior
    - Total structure behavior and complex behavior
    - Hypothesis testing

3. Teaching Structure

One of the best models depicts the role of management flight simulators in the learning process is Sterman's model, based on the double loop learning model (Figure 1) (Sterman 2000).

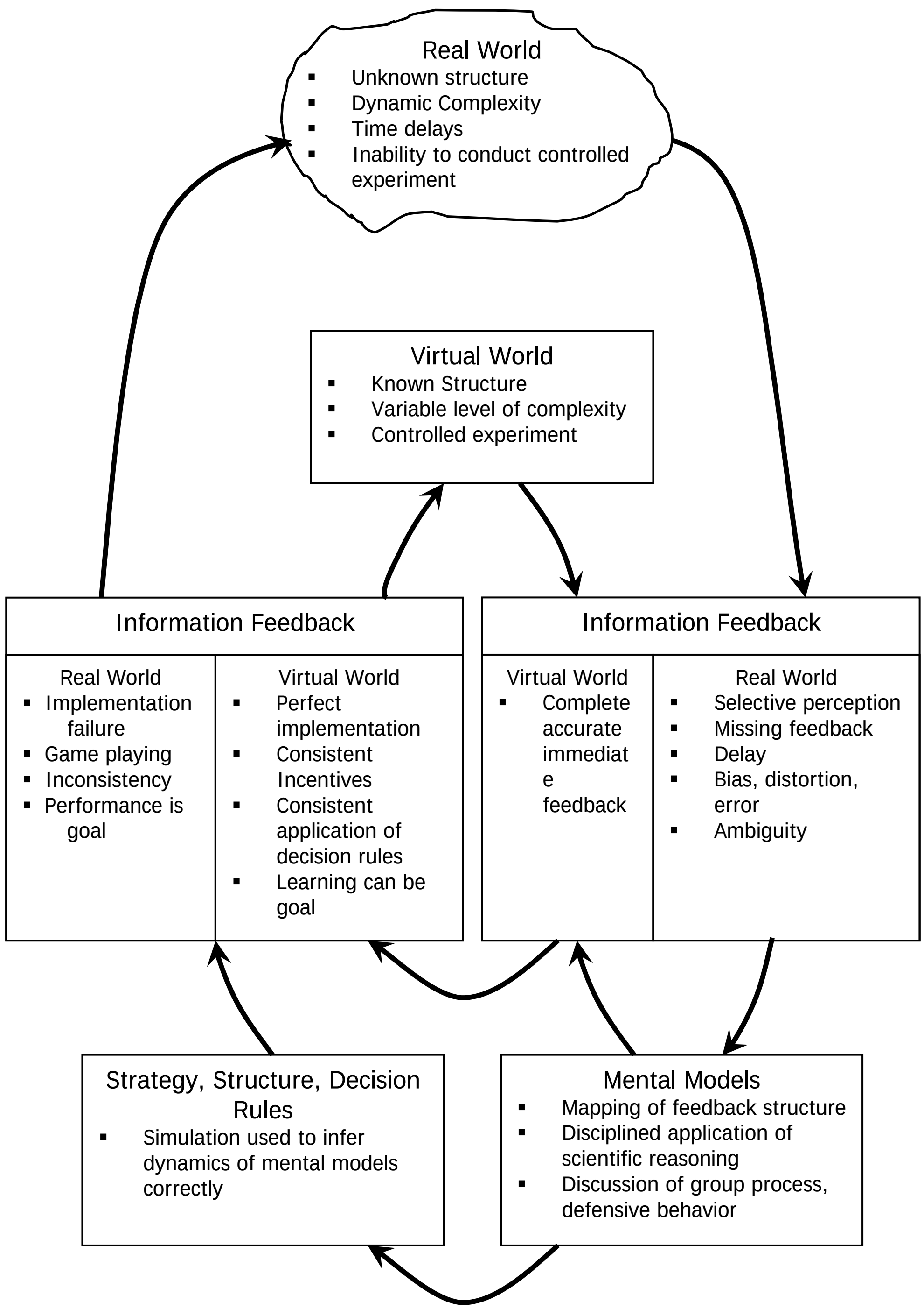

Figure 1: Sterman's model, virtual world role in double loop learning

Some of the useful points which can be understood from this model are:

1- Feedbacks of learner actions must be perfect, immediate, undistorted and complete. They must know why and how something happens.
2- Assumptions must be fully known by the learners.
3- Decisions must be perfectly implemented and their feedbacks must be separated and clear from each other.
4- Experiments must be directed toward learning goals.
5- It must be a balance between think and act. As Sterman (2000) said: “ A commonly observed behavior among modelers and in workshops using management flight simulators is the video game syndrome in which people play too much and think too little.”

But Sterman’s model does not present any methodology for teaching in such environments. Spector and Davidsen (1998, 2000) and Milrad, Spector, and Davidsen (2003) introduced an approach for teaching in SD based learning environments, called MFL (Model Facilitated Learning). In their suggested framework, they describe three stages which a learner should be encountered during the learning process:

1- Problem oriented concrete operations: in the first stage, learner will become familiarized with the simple and typical problems of a complex domain. This stage is mostly problem orientated.
2- Inquiry-based learning: learner will be faced with more complex scenarios and literally begins to see the system structure in a very simplified form such as causal diagrams. It is the first stage of abstraction. It also includes hypothesis formulation and experimentation.
3- Policy-Development: in the last stage, “learners are immersed in full complex system and asked to develop rules and heuristics to guide decision making in order to create stability or avoid undesirable situations.” (Milrad, Spector, and Davidsen, 2003).

They call this “progression from simple and concrete to more complex and abstract” (Milrad, Spector, and Davidsen 2003) as *gradual complexity*. Their point is that facing with complex structures and complex dynamics in the beginning will lead into confusion and mix up.

There are also some learning theories which can be useful for designing a teaching structure for ILEs:

1- Situated Learning Theory (Lave 1988, Lave and Wenger 1991): Lave argues that learning as it normally occurs is a function of activity, context and culture in which it occurs. It has been applied in the context of technology-based learning activities that focus on problem-solving skills (Cognition & Technology Group at Vanderbilt, 1993). In the situated learning approach, knowledge and skills are learned in the contexts that reflect how knowledge is obtained and applied in everyday situations. (Situated Learning in Adult Education. ERIC Digest No. 195)

2- Anchored instruction theory (Bransford and Stein 1993): Anchored instruction is a learning strategy that situates or "anchors" instruction in a realistic case-study, or problem-solving situation. Anchored Instruction challenges and motivates learners to find the story's embedded data thru a realistic, narrative, storyline format. Anchored instruction has become an important paradigm for technology-based learning that has been developed by the Cognition & Technology Group at Vanderbilt (CTGV) under the leadership of John Bransford. Main principles of anchored instruction are:
   a. Learning and teaching activities should be designed around an `anchor' (or situation) which should be some sort of case-study or problem situation.
   b. Curriculum materials should allow exploration by the learner.
   c. Learners should take ownership
   d. Involves complex content, solved through interconnectedness of sub-problems, multiple scenarios presented
   e. Problem presented in a narrative format, a story with embedded data
   f. Learning context is generative (students identify with problem and become actively involved in generating solution)

3- Goal-based scenarios theory (Schank et al. 1994): Goal-Based Scenario (GBS) is a learn-by-doing simulation (either computer-based or live) whereby students pursue a goal by practicing target skills and using relevant content knowledge to help them achieve their goal. Main elements of GBS are: goals, expectations, plans, and expectation failures, explanations, learning goals, mission, cover story, role, scenario operations, resources and feedback.

Considering approaches and theories mentioned above, with regard to our fundamental objectives, we have designed a teaching structure for our own purpose. Here are the main points of our structure:

1- Step by Step approach: The teaching process starts with the basic model of supply-demand interaction (Figure 2). This model will be expanded step by step in different stages. In each stage a new element will be added to the model and the learner will learn the effects of the new element on the behavior of the structure. The learning objectives in three fields of system thinking, economics and system dynamics are determined for each stage and all of these objectives are aligned so they lead the learner toward the whole structure and its behaviors.

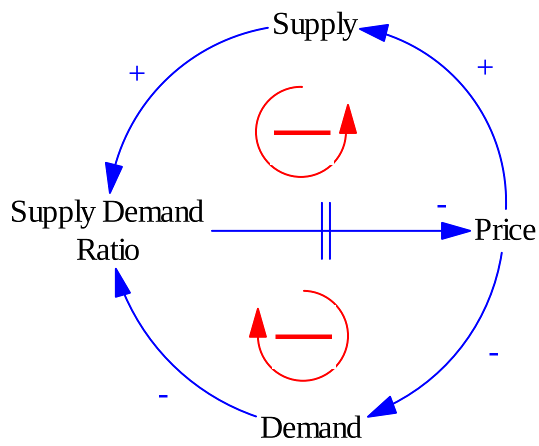

Figure 2: Basic supply-demand causal diagram

2- Multiple methods of teaching: At each stage based on what must be taught, one appropriate method is used. Using variant methods of teaching, prevents learners of becoming bored and makes the whole teaching process more attractive and interesting.
3- Real world problems: We tried to use real problems in the software so the learner will have a sense about the problem and also he will find the usage of each model in analyzing different situations in the real world. Most of the problems and games are in the context of microeconomics such as finding the best supply level, adjusting the inventory or managing the backlog of orders.
4- Interactivity: Interactivity in learning is "a necessary and fundamental mechanism for knowledge acquisition and the development of both cognitive and physical skills" (Barker, 1994). Interactivity is one of the main features of our software. For this purpose we have employed the Microsoft agent Merlin character (Figure 3) which is everywhere with the user to help him with providing different explanation and feedback or giving different hints.

Figure 3: Merlin

5- Game playing: the motivating nature of the games makes the learning process more fun, if not easier. People pursue games with more enthusiasm and they try harder to achieve the goals. Besides, during the game playing, we can measure the ability of learner to use what he had learned and give him/her better feedbacks.

6- Immediate feedback: Learner will get the feedback of each of its actions just after doing it. The feedbacks always come with a vivid description of what happened and why. Feedbacks of different actions will be separated and learner can find what action and what change will lead to what behavior. Furthermore, learner can see his/her results at any time he/she likes and has a good evaluation of his/her improvement during the program.

7- Multimedia support: using the description presented by Ambron and Hooper (1988), multimedia is said to consist of the media (text, audio, and visuals), the technology (computers) and the products (kiosks, education, games and information). *Multimedia technology offers instructional designers an unprecedented opportunity to create richly interactive learning environments* (Kirsh, 1997). Film, Animation, Text, Picture and Sound are all kinds of media which is used in the software to facilitate the process of learning.

4. Models Development

The first version of Supply Demand World (SDW) software consists of 6 models taught in 4 stages. In each stage a new element of the Supply-Demand structure will be introduced and added to the model used in the previous stage. Here is the list of models:

1. Basic supply-demand model
2. Inventory model
3. Hoarding model
4. Backlog and inventory model
5. Production capacity model
6. Competition model

In the next section a brief description of each stage, its model, learning objectives of the stage and the method of teaching is presented.

4.1. Stage 1: Basic Supply-Demand Model

The basic supply-demand model is depicted in figure 4.

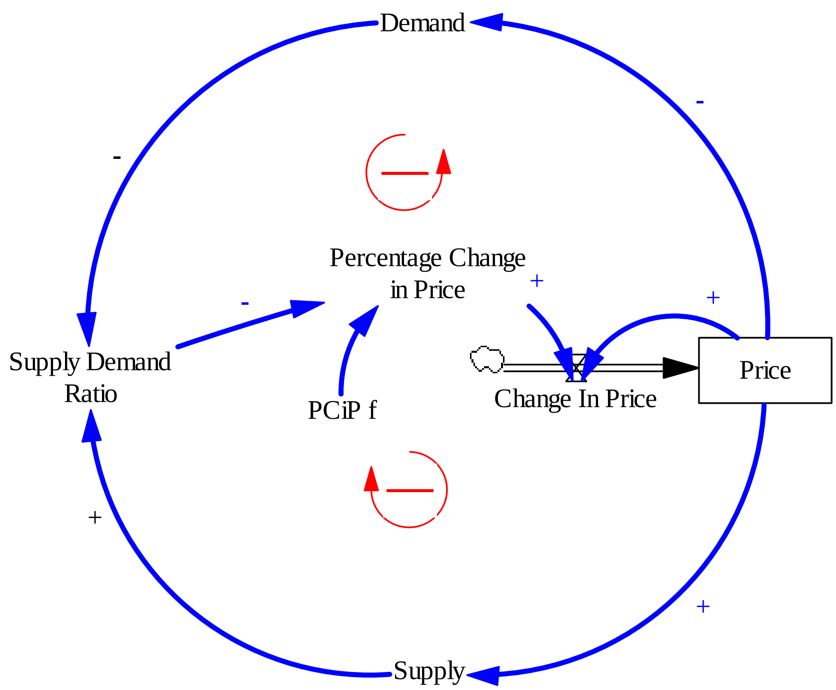

Figure 4: Basic supply-demand model

Learning objectives of this model are:

- Context Objectives
  - Relationship between supply, demand and price
  - Equilibrium and equilibrium price
- System Thinking objectives
  - System as interrelated elements to achieve a goal
  - Thinking over time and relationship between changes of different quantities
  - Cause and effect is underlying element of each change.
  - Cause and effects are positive and negative
  - Causal loops are a closed chain of cause and effects
  - There is accumulation of people, money, material, and … in each system.
  - Accumulation takes place in stocks.
  - Each stock is increased and depleted by flows.
  - Stocks are the sources of delays.
  - Feedback concept and simple feedback structures

In this model the basic elements of supply-demand interaction, their relationships and also the fundamental concepts of system thinking and system dynamics are taught. Teaching process starts with five initial multiple choice questions. During these questions, we draw the learner's attention toward the relationship between supply, demand and price and their interaction in the supply-demand structure. At the end of each question, the complete answer will be showed in the form of an animation. From question 3, before showing the choices, a training room is available for the learner to test the relationship and interaction questioned and the learner has time to try its ideas and finds the true answer (Figure 5).

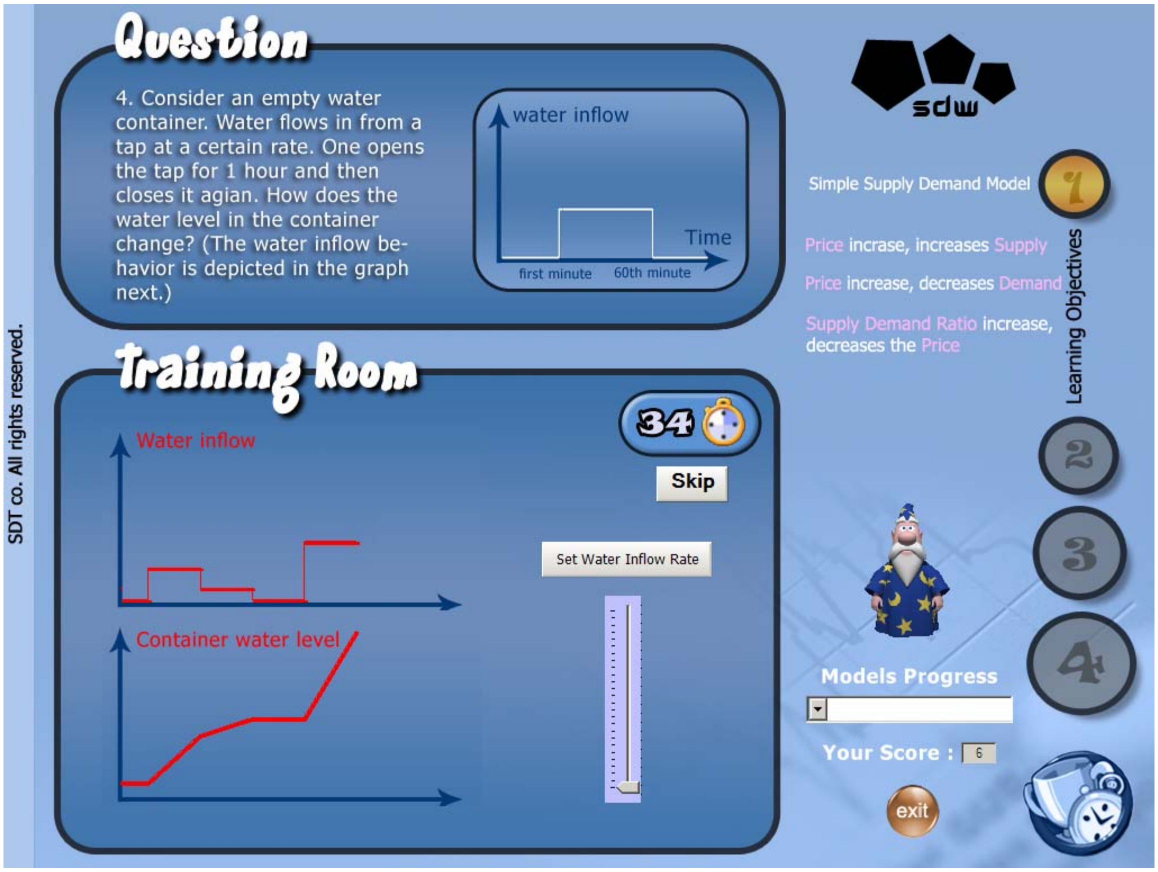

Figure 5, a question and its training room

All the questions are in the context of real world problems. In the first two questions the effect of price change on demand and supply is taught. The third question is about the effect of “supply demand ratio” change on the price. Throughout these three questions, learner will become familiarized with the positive and negative causal relationships, feedback and causal loops. In the forth question the concept of stock and flow variants is presented and at last, in the fifth question, all the concepts taught during the previous questions come together and form the basic model of supply-demand. The fifth answer presents the concept of system, dynamic structure, and dynamic behavior. During the questions learner advancement is evaluated too. At the end of the questions, learner goes through a game (Figure 6). In the game, learner holds the role of the suppliers and must set the supply level with regard to demand changes in order to gain the maximum profit. Maximizing the profit will be practiced in different demand levels; learner should find the new best supply level. During the game, an agent (Merlin character) is present and gives the necessary description about the effects of learner's actions. The game is not only a teaching tool, but a very good evaluation tool for us to appraise the effectiveness of the teaching process. After the game, the right strategy will be taught to the learner and again a brief review of supply-demand structure and equilibrium price will be instructed. Finishing the game, learner will go to stage 2.

Figure 6: First game of basic supply-demand structure

4.2. Stage 2: Inventory Model

Stage 2 starts with the question about the most unrealistic assumption of the previous model. In the previous model excess supply relative to demand is vanished. While in the real world excess supply is accumulated in inventories. We ask about the excess supply and use the answer to prepare the user for the next addition to the model. Second stage consists of 2 games. Learning objectives of stage 2 are:

- Context objectives
    - Inventory and its usage
    - Desired inventory
    - Hoarding
- System thinking and system dynamics objectives
    - Delay concept
    - Overshoot structure and overshoot behavior

Then, the concept of noise will be taught to learner and he will go through the second game where he must minimize his/her costs of over-demand or over-supply in the presence of noise in demand. Through the game the need for the inventory to cover the demand changes will be felt. Describing the inventory concept, learner should add this new element to the basic model (Figure 6). Then with the new model generated (Figure 7), next game begins.

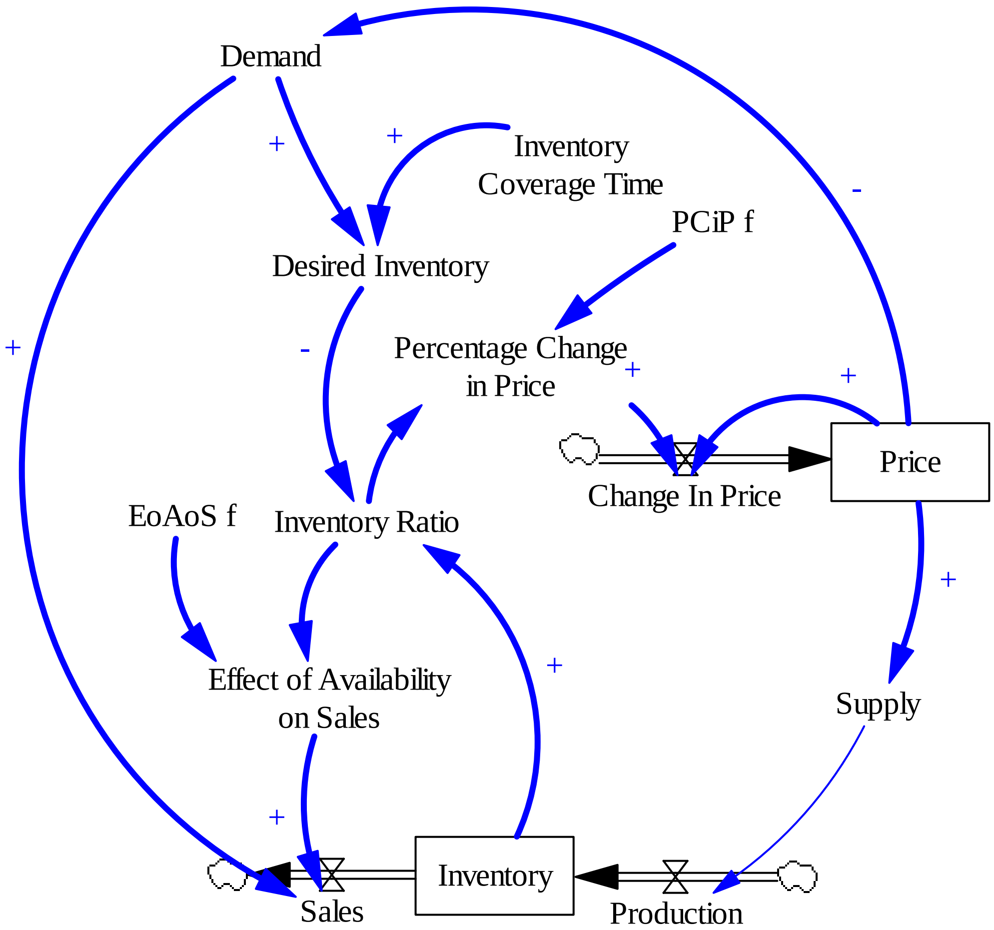

Figure 7, Inventory model

4.3. Stage 3: Backlog and Inventory Model

Like the previous stage, the third stage starts with the question about the most unrealistic assumption of the previous model. In this stage a question about unsatisfied demand is raised. The learner is led to realize that orders are accumulated in backlog and are not lost when there is not enough supply to satisfy them. Adding the backlog to the previous model, new model looks like Figure 8. Learning objectives of the third stage are:

- Context objectives
  - Backlog of demand
  - Backlog deterioration
- System thinking and system dynamics objectives
  - Oscillation behavior and its structure
  - Complex structure and complex behavior

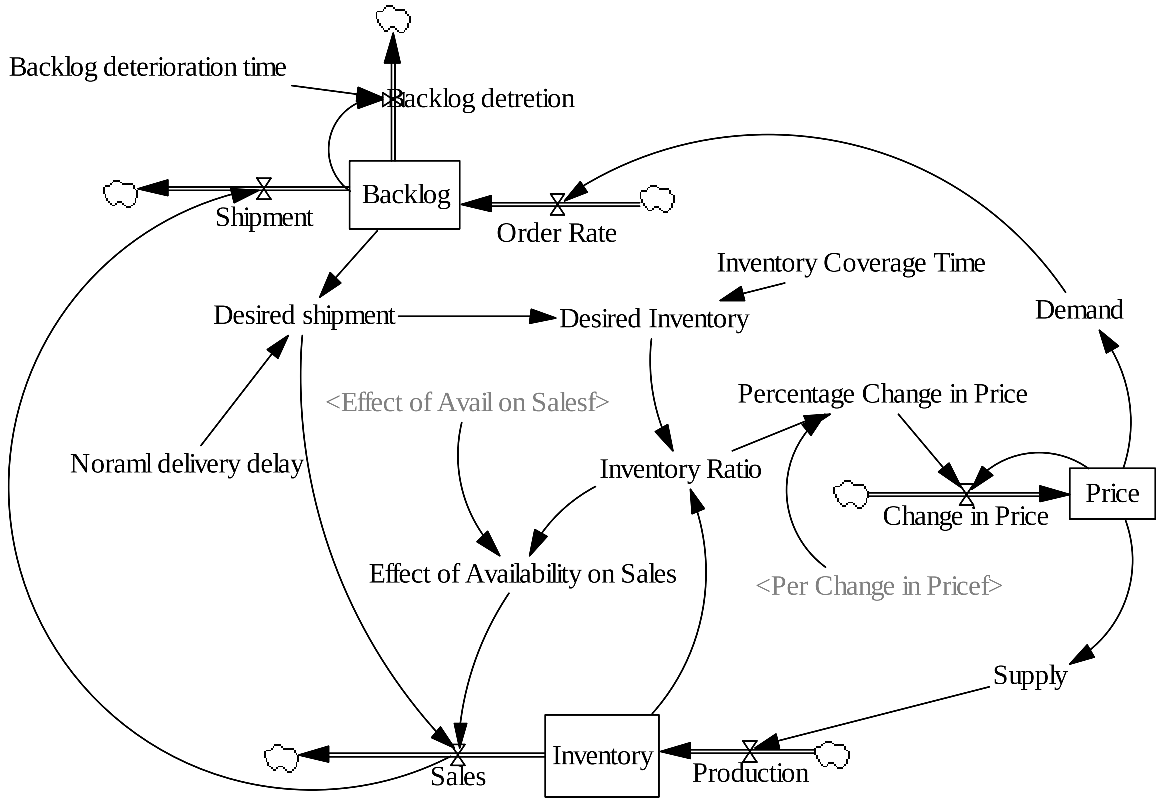

Figure 8: Backlog and inventory model

Third stage follows with an introduction to the backlog concept, its usage and its effect on demand. Learner must complete the model with the new element and then he/she will go through a game in which the learner is in the role of the production manager of a company. The purpose of the game is to control the inventory and desired inventory with regard to the backlog, in order to respond to order changes. In this game, the strategic leverage points of the player are the desired inventory, inventory coverage time and the effect of product availability on sales. By using these leverages, learner should get an acceptable cost in the form of customer lost, plus inventory cost and customer dissatisfaction cost in responding to the demand changes. He/she has enough time to test his/her hypotheses and examines the results. The demand will be in such manner which produces oscillations, so the learner will see the oscillation behavior too. Figure 9 shows a sample simulation and the order function for a simple strategy in which the “desired shipment” is set as “backlog” divided by “normal delivery delay” and “desired inventory” is set as “desired shipment” multiplied by “inventory coverage time”. During the game, the agent will help the learner through finding a good strategy. After the game, the oscillation generic structure and its behavior will be presented and a good strategy for the game will be introduced and he/she goes to the next stage.

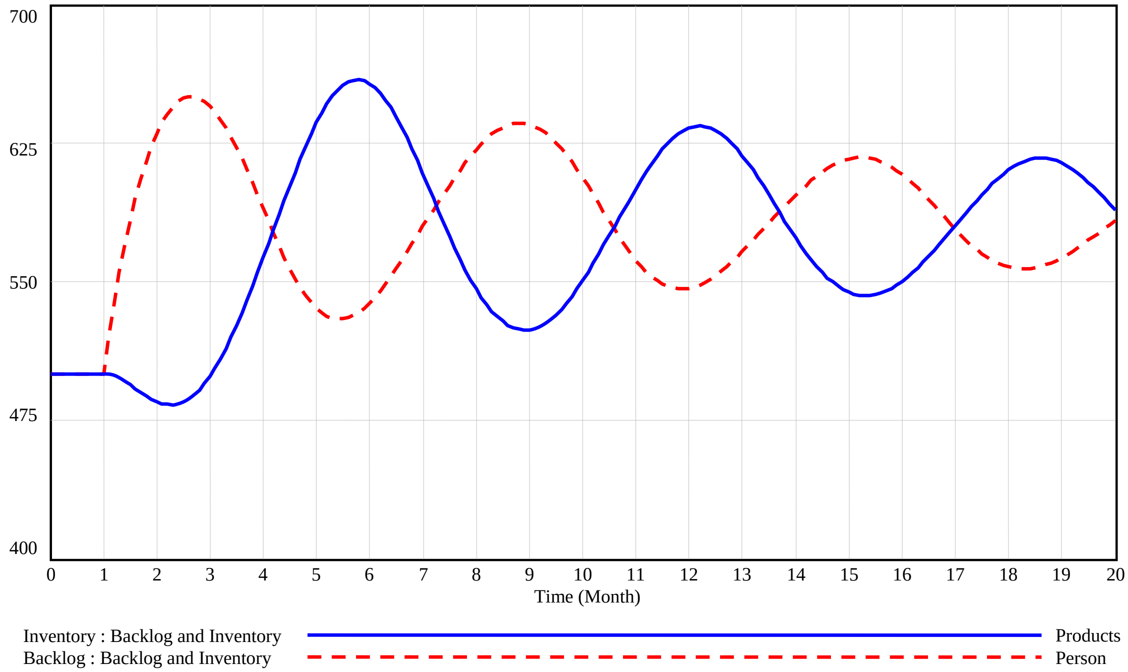

Figure 9: sample simulation for the backlog and inventory game

4.4. Stage 4: Production Capacity

Like previous stages, fourth stage starts with the question about the most unrealistic assumption of previous model. At this point the assumption about immediate change in supply is questioned. The model is modified to relax such unrealistic assumption. Learning objectives of the fourth stage are:

- Context objectives
  - Production capacity and its effects
  - Competitive market and zero profit margin.
- System thinking and system dynamics objectives
  - Total structure behavior

Final stage is composed of a game in which learner learns how to speculate the behavior of a complex model form its structure. At first, the production concept and its role in the supply-demand structure will be presented to the learner through an animation. Based on this introduction, learner would be asked to provide some ideas about adding new elements to the model. The new model is introduced to the model (Figure 10) and then the final game begins. In the final game the supplier should decide about the change in production capacity as well.

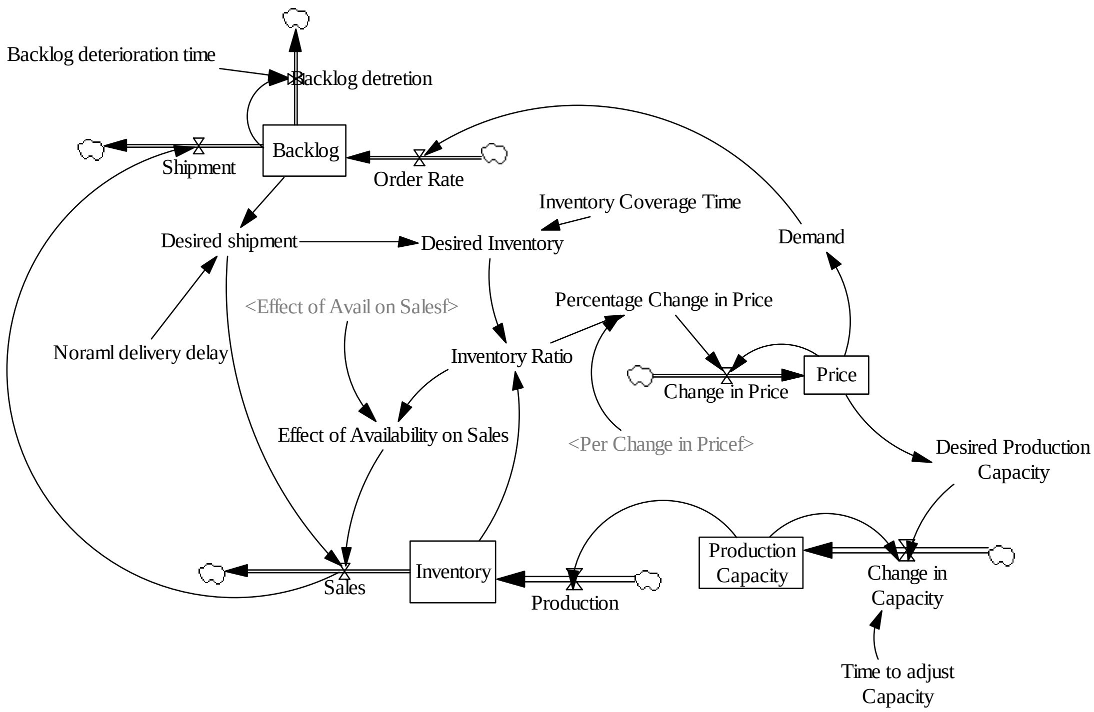

Figure 10: production capacity model

5. Software Features

Here is a list of main features of the software:

- **Review capability:** In each stage of the software, learner can go back and review the previous lessons. “Models Progress” lists all the animations, answers and films showed before. By clicking on each item, that item will be shown again.
- **Software Help:** There is a complete help for all stages of the software. This help is prepared in both HTML and PDF formats
- **Supporting materials:** There are some supporting materials in the fields of system dynamics and elementary microeconomics which can be used beside the software for further readings.
- **Graphical user interface (UI):** The UI design of the SDW software is one of the main strengths of the software (Figure 11). Attractive and user friendly graphical design beside “ease of use” is two factors we tried to pursue in the UI design of the software.

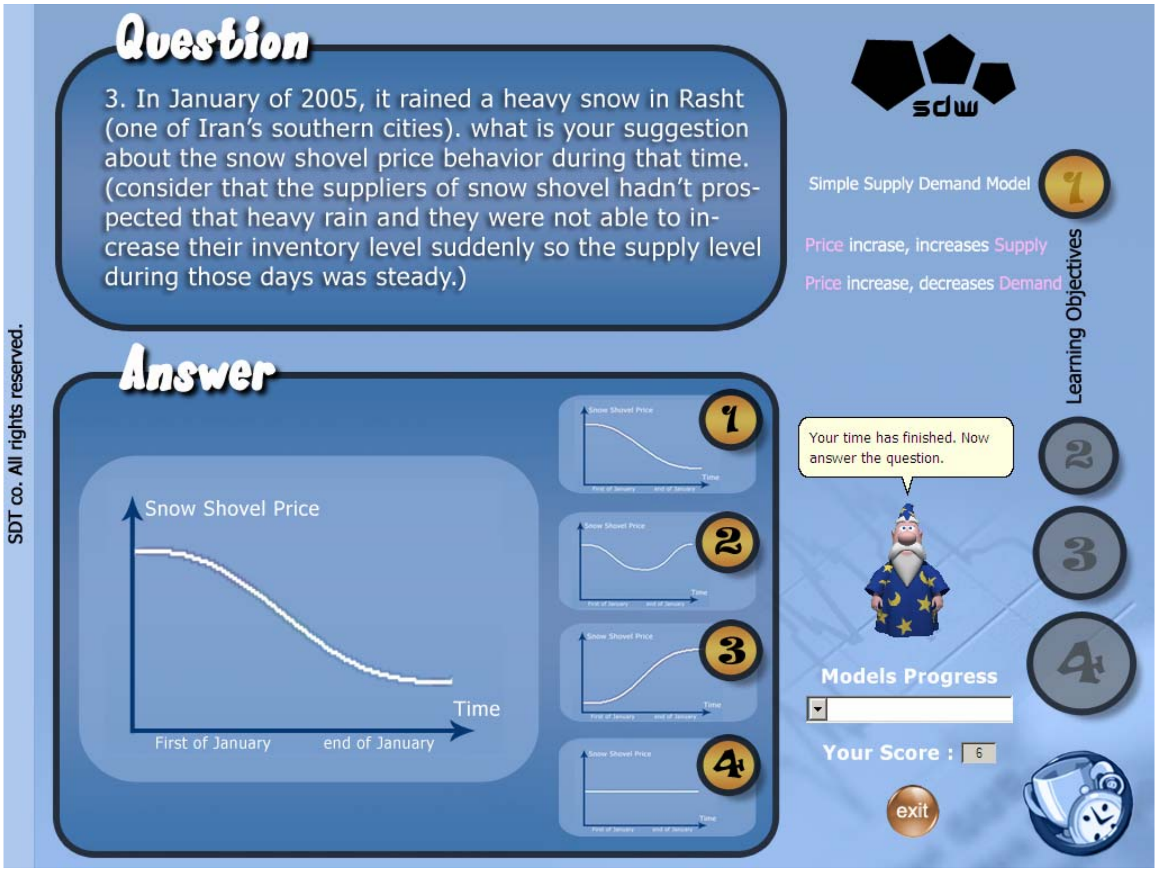

Figure 11: UI design of the software

- **Agent support:** Merlin character (Microsoft Agent) supports learner everywhere during the teaching process and helps him/her in solving the problems and finding the right strategies.
- **Multi-User:** each new learner can define his/her own user in the software. A unique username and password will assigned to each user and he/she can login by his username and password. This capability allows different users to work simultaneously with their own scores and information without having their data mixed.

6. Software Structure Summary

Giving a complete description about "Supply Demand World (SDW)" software architecture is out of the scope of this paper. Here is a summary of the main points of the software structure.

The software is written with Microsoft Visual Basic.Net and is compatible with windows XP/2000/2003. It needs .Net framework (version 2003) installed on the windows which will be installed during the software installation. Design of the software is based on Object Oriented (O.O) design and it allows software to easily edited and completed later. After running the software, user must enter his/her username and password to login to the software. Figure 12 depicts the main page of the software. There are four buttons (besides exit button) in the main page leads the user to the related page: introduction, teaching, help and supporting materials. In each page there is a back button returns the user to the main page. All the users' information, results and actions are stored in a database. Each time a user logins the software, his/her information is read from the database and he/she can continue from the point he/she left last time. More information about the software is described in table 1.

Compatibility	Microsoft Windows XP/2000/2003
Application type	Windows Application
Database format	Microsoft Access Database
Approximate size of the setup package	
Approximate size of the installed package	

Table1, Software characteristics

Figure 12: Main page of the software

7. Teaching Effectiveness

To assess the effectiveness of the software, two groups of high school students, from two different classes, have been asked to answer 7 questions in the fields of system thinking, system dynamics and economics. Table 2 summarizes the subject demographics. The two groups were quite similar.

Table 2, Subject demographics

	Group 1	Group 2
N	14	14
Average Age	16	16
Gender	M	M
Student Status	2nd year of high school	2nd year of high school
System dynamics experience	No	No
Economics experience	No	No
Average last year GPA	17.4 from 20	17 from 20

The list below shows the specific system thinking skills and economics concepts which have been questioned.

- System as interrelated elements to achieve a goal
- Thinking over time and relationship between changes of different quantities
- Cause and effect is underlying element of each change.
- Cause and effects are positive and negative
- Causal loops are a closed chain of cause and effects
- There is accumulation of people, money, material, and ... in each system.
- Accumulation takes place in stocks.
- Each stock is increased and depleted by flows.
- Feedback concept and simple feedback structures

The questions were simple and were about the real life problems which the students were familiar with. The first group had no experience of working with the software or passing any economics or system dynamics course before. The students in the second group also had no experience of any system dynamics or economics course, but they worked with the fist stage of the software for one hour and then answered the questions. The performance of two groups is summarized here:

- Question 1: The first question was the bath-tub question, Sterman (2000) used in the "Initial Results of a System Thinking Inventory" to measure the level of understanding of stock and flow concepts. About 40% in the second group worked with the software, answered the question correctly in comparison with 0% in the first group. Better analyzing the answers, indicates that about 50% of the students in the second group understood the concept of accumulation compared to 20% in the first group.
- Question 2: The second question was about the understanding of the growth behavior of a product price due to the banning of its substitute product. In the first group about half of the students correctly showed the price rising but only about 10% noticed the new equilibrium concept. In contrast, all the students in the second group drew correctly the growth

behavior of the price and about half of the students noticed that the price will become steady at last.

- Question 3: In the third question, the concept of price growth as a result of excess demand was asked. Only about 30% of the subjects in the first group pointed out the excess_demand idea as the reason of the price growth in comparison with the 80% of the subjects in the second group. Also the fraction mentioned the middlemen as the cause of the "price growth", instead of using the excess__demand structure, reduced significantly in the second group (approximately from 70% in the first group to 10% in the second group).
- Question 4: The forth question was about the black market and excess-demand structure. Similar to the previous question, only about 20% in the first group mentioned the excess-demand as the reason of the black market compared to 80% in the second group. Again, about 80% of the students in the first group mentioned the middlemen acts as the cause of the black market which this fraction reduced to 20% in the second group.
- Question 5: In the fifth question, the graphs of the inflow and outflow rates of the customers of a department store were depicted and the students were asked to find the time related to the maximum and minimum number of flows and total customers in the department store. About all the students in both groups answered the parts (a) and (b) of the question about the maximum and minimum of the rates correctly. No one in the first group answered parts (c) and (d) of the question about the maximum and minimum of the total customers in the department correctly, but about 20% of the subjects in the second group gave a correct answer to these parts.
- Question 6: In the sixth question, students were asked to draw the price behavior of a product after its export was banned. About 80% in the first group correctly showed the decrease in the price compared to the 70% of the subjects in the second group. But only 20% in the first group observed the new equilibrium versus the 60% in the second group.
- Question 7: In the last question, a story about the emergence of a new product and the overshoot in its number of suppliers was described and the students were asked to describe the reason of the overshoot. Only 20% of the students in the first group mentioned the over-supply and delay as the causes of the story, but about 60% of the students in the second group used the supply-demand structure correctly to depict the behavior of the overshoot.

The results show that the first group was almost unable to see the structures behind the behaviors. The linear and event based thinking is the dominant way of analyzing the simple economics problems. No evidence of any systematic thinking observed in the answers of the first group. Poor understanding of basic economics concepts and system dynamics concepts specifically, stock and flow, feedback and time delays were clear. The second group showed much better results in understanding the economics phenomena and using system thinking skills in solving simple economics problems. Perceiving the behavior of variables during the time and identifying the causal relationships and causal structures were much apparent among the second group worked with the software. Here are some other facts resulted from the assessment:

- The fraction of students who recognized the concept of stock and flow was much larger in the second group worked with the software compared to the first group.
- The subjects in the second group noticed more the total structure of the supply-demand in answering the questions, but in the first group the answers were rather based on the change of only one identity.
- The results show that students in the second group paid more attention to the equilibrium concept.
- There is no use of the concept of "supply demand ratio" in the answers of the first group but in the second group more students used the concept to answer the questions.

Though the our sample was not large enough, but it can show the good effect of using the software in understanding the dynamic aspect of economics. Further experiments and assessments will lead us toward better understanding of the effectiveness of the software and its weaknesses and difficulties.

8. Conclusion and Further Research

"Supply Demand World" is an Interactive Learning Environment, applies system thinking and system dynamics concepts and some learning theories to the microeconomics teaching methods. The teaching structure is based on some learning theories and the capabilities that the computer gives us to support the teaching process.

Up to now the first stage of the software in the context of Supply-Demand sector has been released and we are trying to finish the design and programming of other stages to extend the software.

Its effectiveness has been tested once and seems to be helpful in teaching the basic system dynamics and supply-demand structure concepts. More experiments will be performed to get better insight of the effectiveness of the software and its weaknesses to improve the software.

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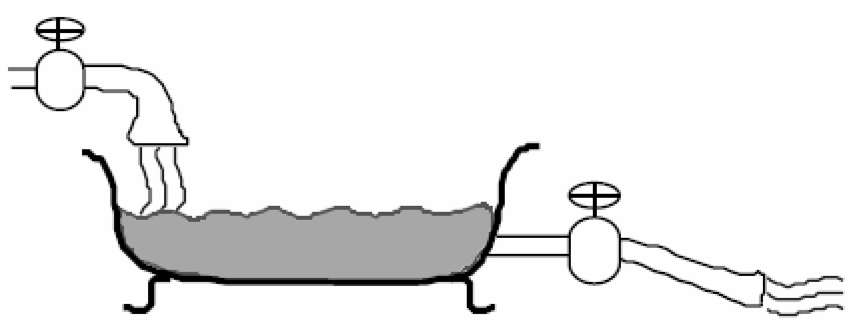
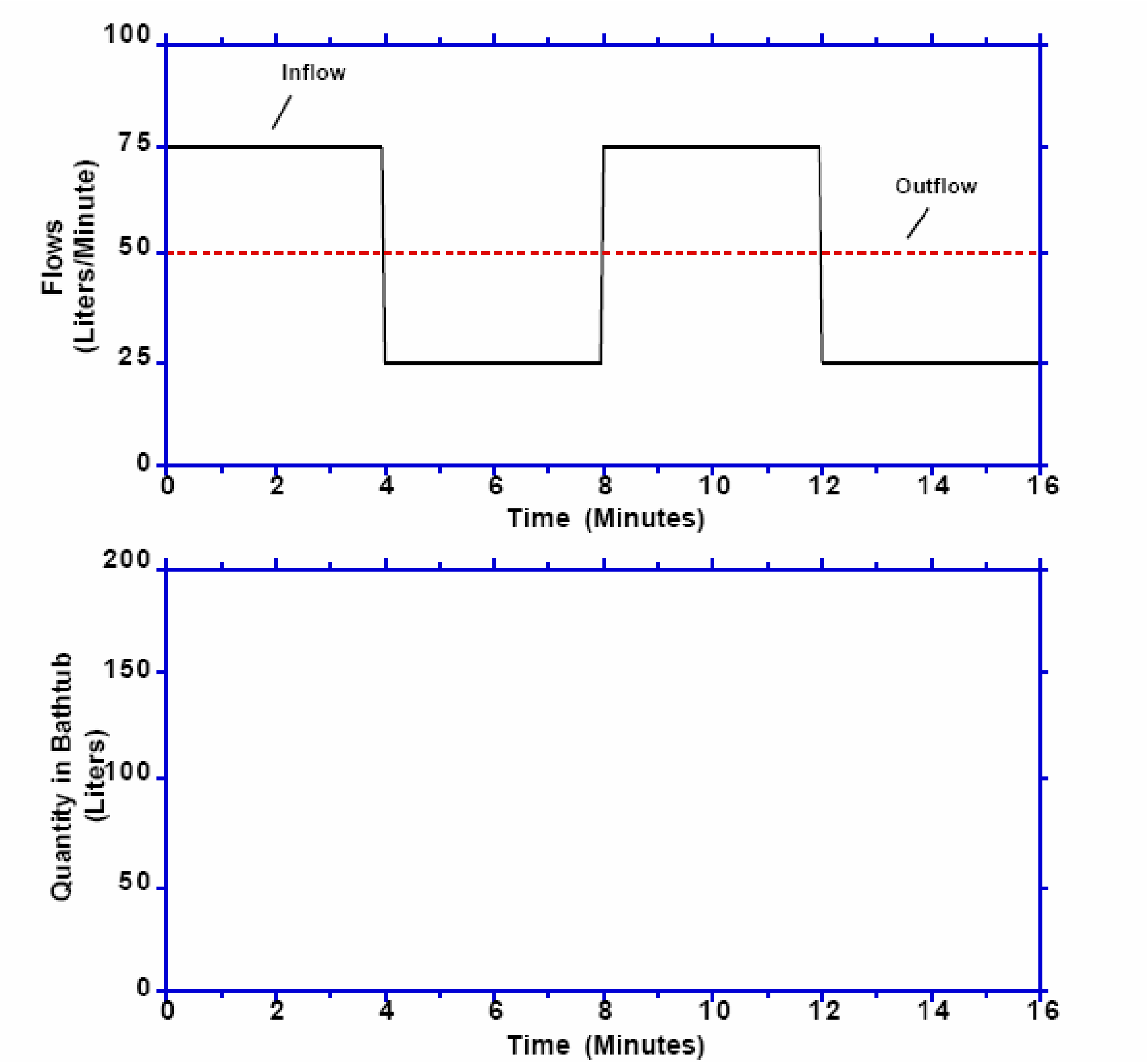
Appendix: Questionnaire Form

The Questionnaire Form

1. Consider the bathtub shown below. Water flows in at a certain rate, and exits through the drain at another rate:



The graph below shows the hypothetical behavior of the inflow and outflow rates for the bathtub. From that information, draw the behavior of the quantity of water in the tub on the second graph below. Assume the initial quantity in the tub (at time zero) is 100 liters.

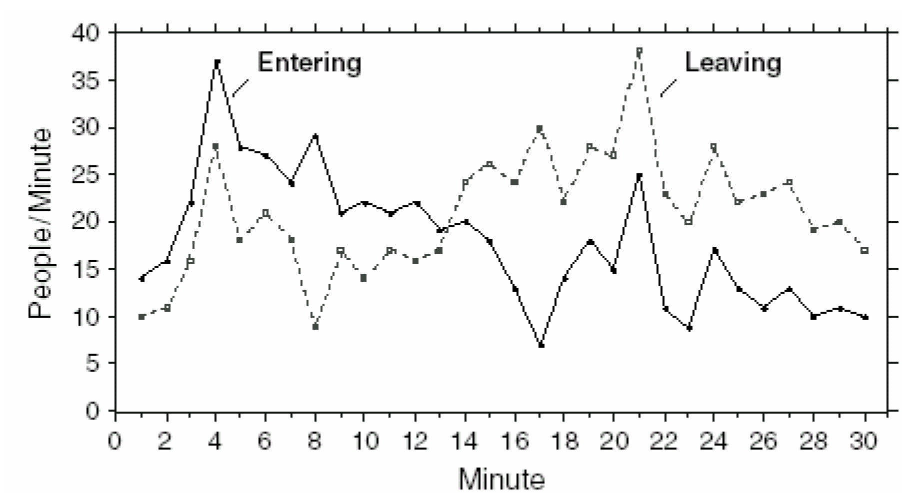


2. Suppose that because of the mad-cow disease, the supply of meat would be banned. What is your suggestion about the behavior of the price of the chicken? Please depict the price behavior for chicken and explain your results.

3. What do you think about the main causes of the huge price growth of the fruits just before the Nowrouz (Iranian New Year Period)

4. Every year, during the “Fajr Film Festival”, we can see that the tickets of the films are sold with a much higher price than the formal price just in front of the cinemas, or in other words, there is a black market for the films tickets. What do you think about the reasons of this phenomenon?

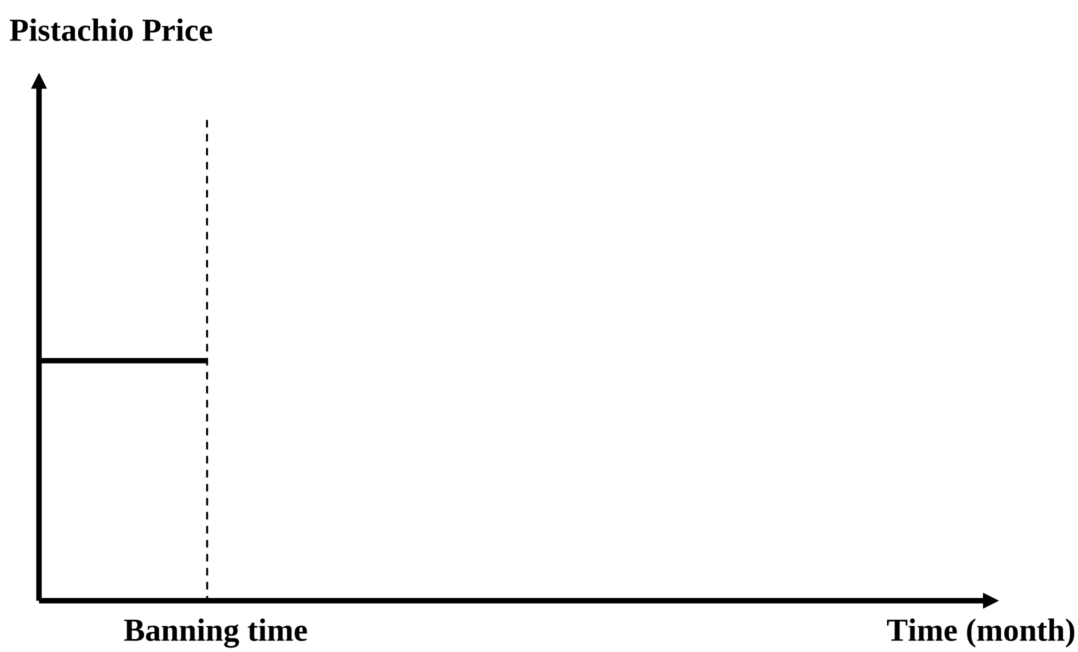
5. The graph below shows the number of people entering and leaving a department store over a 30-minute period.



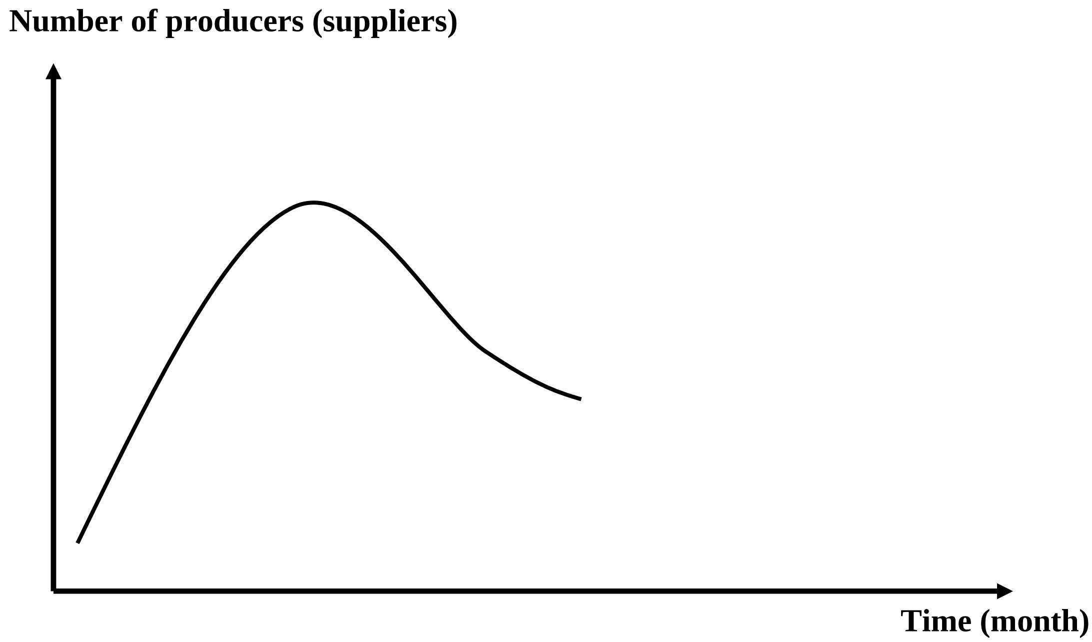
Please answer the following questions

a. During which minute did the most people enter the store?
Minute _______
b. During which minute did the most people leave the store?
Minute _______
c. During which minute were the most people in the store?
Minute _______
d. During which minute were the fewest people in the store?
Minute _______

6. In the year 2001, due to not observing some food standards, the export of Iranian pistachio was banned. As a result, all the pistachios entered into domestic market. What do you think about the behavior of the price of the pistachio in domestic markets after this event? Draw the behavior of the price in the below graph.



7. When a new successful product enters into the market and people become interested in it, because of the high demand for the product and also the limited supply level of the product, its price will rise dramatically and this results in a high profit for the producers. Because of this large profit, many companies will try to produce that good to have a share of its high profit. The phenomenon which happens most of the time is that the number of the suppliers of the emerging product rises rapidly and then it begins to decline. This phenomenon is depicted in the graph below. How do you describe the reasons of this behavior?


Number of producers (suppliers)
Time (month)