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ABSTRACT

This paper reports a project being conducted in collaboration with teachers and administrators in an elementary school in an affluent suburban school district. The purpose of the project is to formulate a theory of curriculum change that will be useful to people in the school, the school district, and the community interested in intensifying the integration of computer technology in the teaching of various subjects in the school. The central hypotheses highlight the importance of teachers and student learning as powerful factors in the success or failure of the computer integration effort. In summary, while there are many potential self-reinforcing loops which could be harnessed to generate growth in the use of computer for instruction in the elementary school under analysis, growth is ultimately bounded by financial constraints related to the willingness of the community to bear the tax burden and by the willingness of teachers to put in the preparation time required to take advantage of the potential of computer instruction to enrich and individualize instruction. A list of factors influencing the integration of computer technology into instruction is appended. (AEF)

A Theory of Curriculum Change in Schools: The Case of Integrating Computer Technology into Instruction in a Suburban Elementary School

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Boston University
April 17, 1998

The Project

This paper reports a project being done in collaboration with teachers and administrators in an elementary school in an affluent suburban school district. The purpose of the project, still in progress, is to formulate a theory of curriculum change that will be useful to people in the school, the school district, and the community interested in intensifying the integration of computer technology in the teaching of various subjects in the school. While computers are widely used in the businesses and professions of the parents of children in the school, and widely present in the children's homes, computers are little used in teaching and few teachers in the school are skilled in using computers and thoughtful about the possibilities for integrating them into their teaching.

Dating back to 1982, the school district has constituted several task forces, each of which has issued a report, in an effort to conceptualize and implement greater integration of computer technology in instruction. Members of the task forces have been very knowledgeable about education and computers, in addition to which the town is in process of installing a computer network covering town offices, the town library, and the schools; however, the level of use of computers in teaching remains low. Thus, the focal problem can be represented in terms of a growing discrepancy between the use of computers by citizens in the community and the integration of computers into the curriculum of the school (Figure 1).

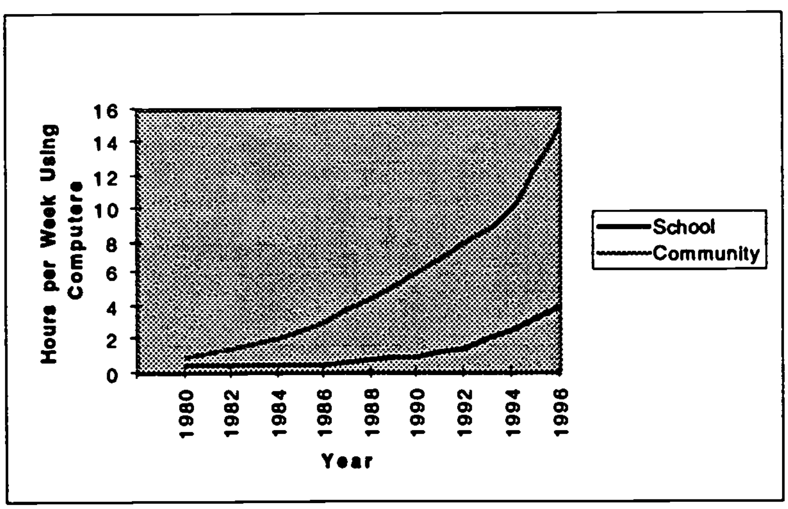

Figure 1. The Growing Discrepancy in Computer Use between School and Community.

Methodology

Drawing on an extensive literature on organizational change in schools[1] and on insights from repeated interviews with the school principal and interviews with the assistant superintendent for instruction and two teachers, as well as the task force reports, an extensive set of hypotheses was formulated about the factors and relationships influencing the integration of computer technology into teaching in the school. A list of factors in included in Appendix A. The essential relationships represented in the model are described in the following brief descriptions.

1. Computer use tends to be self-reinforcing through increasing (a) teacher and student skills, (b) amount and complexity of software suited to different subject matters and supporting enriched and individualized instruction, (c) numbers of computers and amount of software, (d) class time spent using computers, and (e) community support for using computers for instruction.

2. Computer use tends to be limited by costs of hardware, software, training, and facilities and by demands on teacher preparation time related to changes in the degree of enrichment and individualization of instruction.

3. Community support for using computers for instruction is influenced positively by the importance of computers in the wider world.

4. School finances are constrained asymptotically by the tax rate as a fraction of the maximum tax rate acceptable to the community.[2]

5. Use of computer software for instruction is positively influenced by teacher perceptions of its effectiveness in achieving their instructional objectives.

6. In summary, while there are many potential self-reinforcing loops which could be harnessed to generate growth in the use of computers for instruction in the elementary school under analysis, growth is ultimately bounded by financial constraints related to the willingness of the community to bear the tax burden and by the willingness of teachers to put in the preparation time required to take advantage of the potential of computer instruction to enrich and individualize instruction.

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[1] See, for example, (Baldridge, 1975; Baldridge & Deal, 1983; Berman, 1981; Berman & McLaughlin, 1975; Charters & Pellegrin, 1972; Crandall & Loucks, 1983; Evans, 1996; Firestone & Corbett, 1988; Fullan, 1985; Fullan, 1991; Fullan & Pomfret, 1977; Gaynor, 1977; Hall & Hord, 1984; Havelock, 1973; House, 1981; Huberman, 1983; Huberman & Miles, 1982; Huberman & Miles, 1984; Klein, 1967; Louis & Sieber, 1979; Miles, 1983; Rogers, 1983; Rosenblum & Louis, 1981; Sarason, 1971; Smith & Keith, 1971; Weick, 1982; Wolcott, 1977; Zaltman & Duncan, 1977)

[2] That is, the closer the tax rate gets to the theoretical limit of the maximum acceptable tax rate, the harder it becomes politically to raise taxes any further.

The central hypotheses highlight the importance of teachers and student learning as powerful factors in the success or failure of the computer integration effort. Seemingly obvious, such understandings are frequently overlooked in curriculum reform efforts. From reflection on these hypotheses, a general hypothesis was developed to describe the overall dynamics affecting the use of computer technology in teaching. According to this "dynamic hypothesis," there are a number of factors that build upon each other, in what are called "positive feedback loops," either to increase or decrease the rate of integrating computers into instruction.

Such feedback loops are analogous to those that drive inflation and depression (for example, the so-called wage-price spiral, when the labor supply is tight and there are no other factors exerting pressure to hold prices down). By way of illustration, we hypothesized such a type of relationship among "Funds Available for Computers in Instruction," "Amount of Software Available for Instruction," "Training" (of teachers), "Teacher Knowledge and Skills," "Teacher Perceptions of the Instructional Suitability of Computers," "Complexity of Computer Applications Used in Instruction," "Degree of Enrichment and Individualization of Instruction," and "Student Learning Rate" (Figure 2). These factors are configured theoretically in a positive feedback system constituted of a number of interlocking positive feedback loops. As one factor grows, it exerts upward pressure on the others; by contrast, if one factor declines, it tends to pull the others down, too.

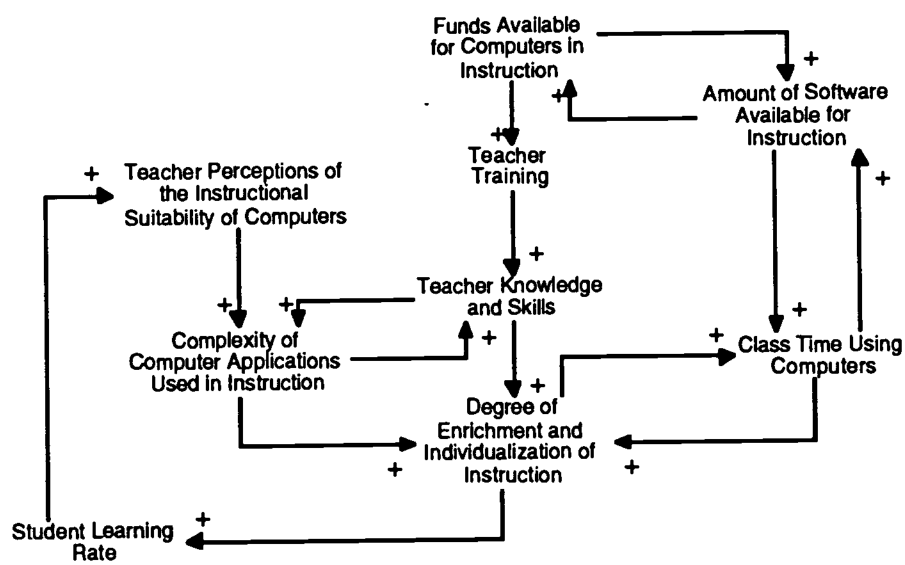

Figure 2. Illustrative Positive Feedback System.

The dynamic hypothesis also incorporates the idea that the "problem system" incorporates little thermostat systems which, like those that control heating and cooling in one's home, work to maintain certain *status quo* conditions. One, for example, resists changes in the ratio of "Required Teacher Preparation Time" to "Teacher Discretionary Time" (Figure 3). As in the previous example (Figure 2), the positive relationships are reinforcing. Thus, "Class Time Using Computers" reinforces the "Degree of Enrichment

Teacher Preparation Time to Teacher Discretionary Time." However, the cycle of reinforcement is broken in the next paired relationship, in which the causal effect is shown as negative (inverse) instead of positive (direct).

The effect of this is to limit the degree of enrichment and individualization of instruction and class time using computers in order to keep required teacher preparation time with whatever zone of acceptance exists among teachers in the school. Thus, the model portrays an interlocking set of reinforcing and limiting feedback loops including these that, according to the theory, influence the course of curriculum change in the school (Figure 4).[3]

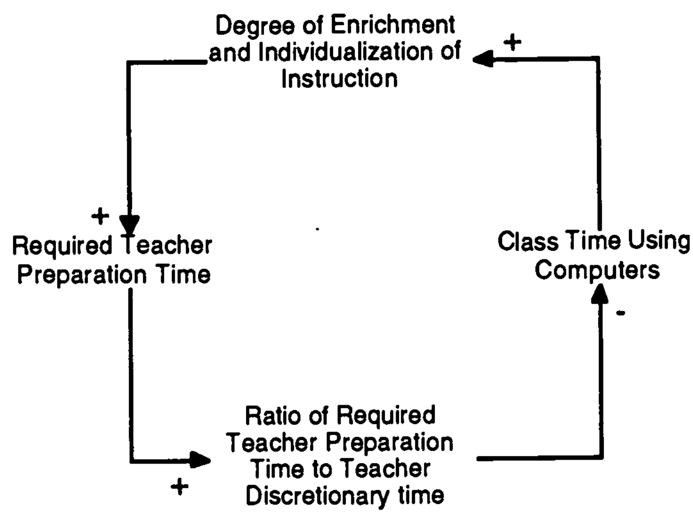

Figure 3. Illustrative Negative Feedback System.

Summary and Conclusions

Based on the literature on organizational change in schools and interviews with teachers and administrators in an affluent suburban school district, hypotheses were put forward about the factors influencing the introduction and integration of computer technology in an elementary school (Appendix A) and the relationships among those factors. A causal-loop diagram was formulated depicting these factors and relationships visually (Appendix B) and, based on this causal-loop diagram, a set of sector flow diagrams was defined as a basis for writing model equations (see Appendix D for the equations for the student and teacher sectors). Many of these equations describe tables of relationship that characterize mathematically the effects of some variables on others.

[3] For a fuller discussion of systems thinking and system dynamics modeling, see Gaynor, A. K. (in press). *Analyzing problems in schools and school systems: A theoretical approach.* Mahwah, N.J.: Lawrence Erlbaum.

While it is hoped that the paper suggests the possibilities of the system dynamics method for theorizing in education and the social sciences, the present work is incomplete at this point in time. However, hopefully, what is visible to the reader, even at this incomplete stage of development, is the extent to which such models expose systematically the structure of a theoretical position both in terms of the variables that define the boundaries of the theory (i.e., those that are included in it and those that are not) and the mathematical specification of hypothesized relationships (even where the theoretical understandings are largely qualitative and speculative and the precise effects among variables are not known with certainty).

Not only are such models more clearly open to critical examination than verbal models at the level of construct validity–because mathematical computer models can be run so as to produce outputs in the form of tables and graphs containing longitudinal data–but also the coherence and predictive validity of such models can be tested in ways not available in examining less rigorous theoretical expositions.

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Appendix A: Hypothesized Factors & Relationships

Factors

Administrative support

Administrative support for teacher integration of computers into their instruction will be influenced by:

1. The expectations of the parents.

2. The extent to which administrators inherently value computers as an object of instruction in schools.

3. Administrators' beliefs about the value of computers in enhancing basic student learnings.

4. What administrators know about computers in general, including their computer skills.

Budgetary constraints

1. Investments in computers and training will be subject to budgetary constraints.

2. Purchases of computer facilities, equipment, and software will be financially constrained.

Community expectations

1. Community expectations for computer use in the school are influenced by the community's awareness of computer use in other schools and school districts.

2. Community expectations for computer use in the school are influenced by the degree of computer use in the community.

3. The community is sensitive to costs.

Computers in students' homes

1. The availability of computers in students' homes is influenced by the integration of computers into instruction in the school.

2. The availability of computers in students' homes is influenced by the availability of computers in the school. (May cut both ways.)

Investment in computers

1. Investment in computer resources is influenced by the school systems support for the integration of computers in instruction.

Rewards and incentives

1. Rewards and incentives for integrating computers in instruction are influenced by the school system's support for it.

School system support

1. The school system's support for the integration of computers in instruction in the school is influenced by state standards, if any.

2. The school system's support for the integration of computers in instruction in the school is influenced by the community.

3. The school system's support for the integration of computers in instruction in the school is influenced by budget considerations.

4. The school system's support for the integration of computers in instruction in the school is influenced by School Committee politics.

5. The school system's support for the integration of computers in instruction in the school is influenced by the teachers.

Teacher attitudes

1. Teacher attitudes regarding the use of computers in the school will affect the degree to which they integrate computers into their instruction.

2. Perceptions concerning ease of use will be influenced by teachers' knowledge and skills related to computers and computer software.

Teacher integration of computers into instruction

Teacher integration of computers into their instruction will be influenced by:

1. External rewards and incentives.

2. Student computer skills.

3. The availability of computers for instruction.

4. The availability of computers in students' homes.

5. The availability of necessary materials and equipment.

6. The availability of software in their fields of instruction.

7. The belief that computer literacy is an important basic skill.

8. The degree to which other teachers in the school use computers in their teaching.

9. The degree to which other teachers in their subject fields use computers in their teaching.

10. The degree to which their students use computers.

11. The ease of use of computers and software.

12. The expectations of other teachers.

13. The expectations of the administration.

14. The expectations of the parents of their students.

15. The expectations of the students.

16. The extent to which teachers inherently value computers as an object of instruction in schools.

17. The software in their fields of instruction that is available in the school.

18. The technical support they get to do it.

19. The training they get to do it.

20. Teachers' beliefs about the value of computers in enhancing basic student learnings.

21. What teachers know about computers in general, including their computer skills.

22. What they know about using computers in their fields of instruction.

Technology environment

1. Changes in the global computer environment will affect the community's expectations for the school.

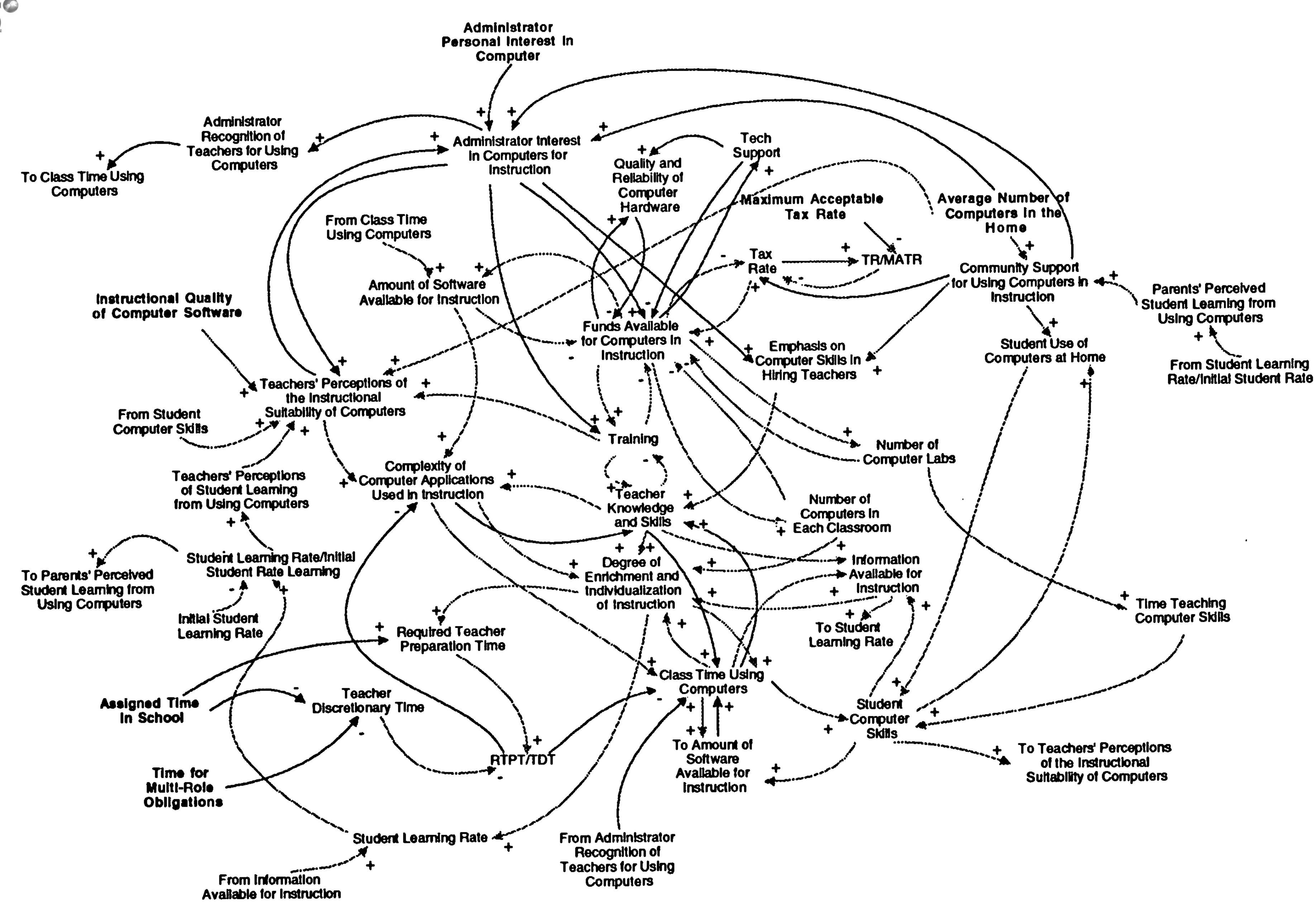
2. The availability in the school of software in different fields of instruction is influenced by knowledge of the nature and quality of "what's out there."

3. Knowing what's out there is influenced by time and effort expended to examine and evaluate software in the different subject areas.

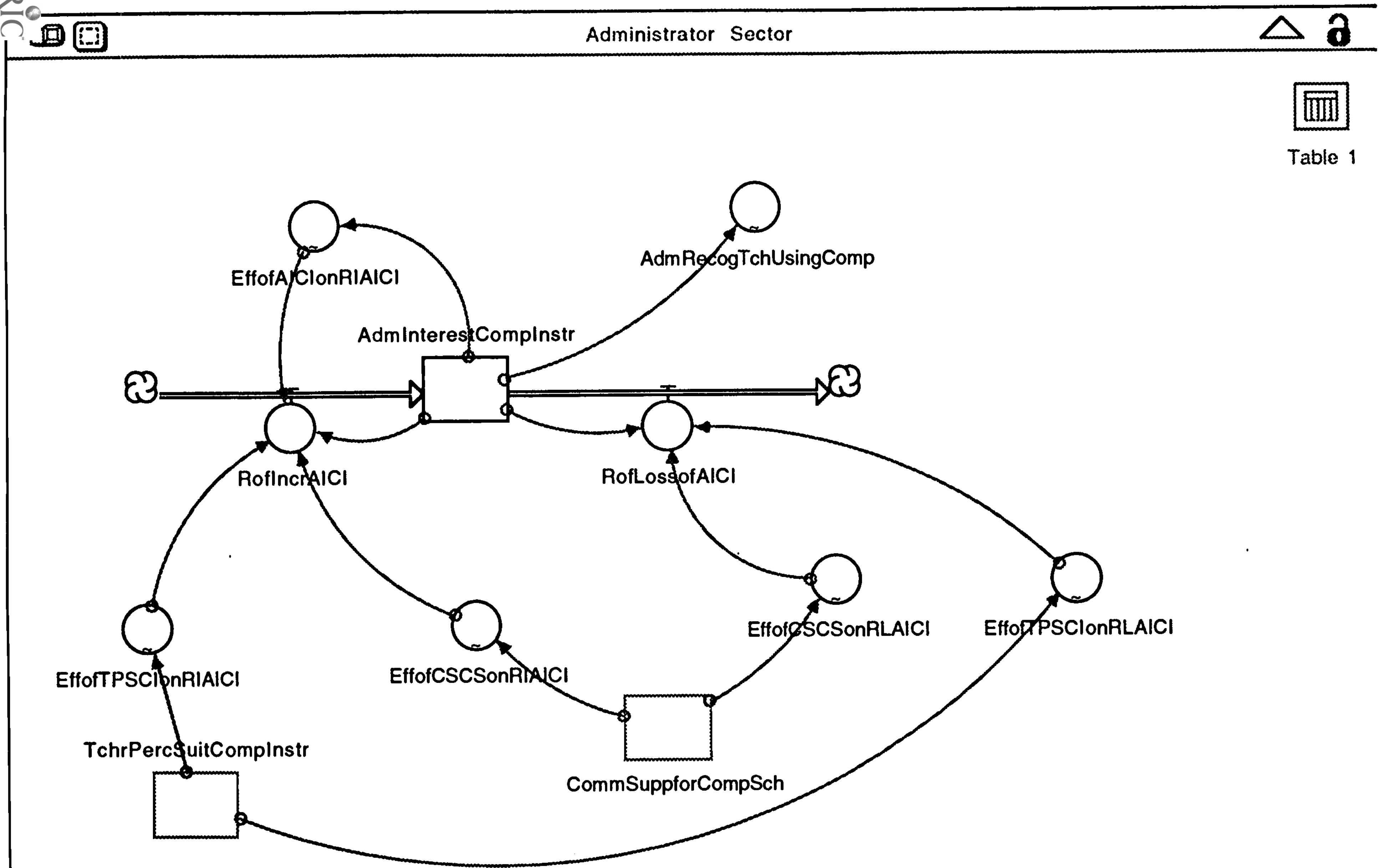
Training

Training for integrating computers in instruction is influenced by the school system's support for it.

Appendix B: Full Causal-loop Diagram


Administrator Personal Interest in Computer
Administrator Interest in Computers for Instruction
Administrator Recognition of Teachers for Using Computers
To Class Time Using Computers
Tech Support
Quality and Reliability of Computer Hardware
Maximum Acceptable Tax Rate
Average Number of Computers in the Home
Tax Rate
TR/MATR
Community Support for Using Computers in Instruction
Parents' Perceived Student Learning from Using Computers
From Student Learning Rate/Initial Student Rate
Student Use of Computers at Home
From Class Time Using Computers
Amount of Software Available for Instruction
Instructional Quality of Computer Software
Funds Available for Computers in Instruction
Emphasis on Computer Skills in Hiring Teachers
Teachers' Perceptions of the Instructional Suitability of Computers
From Student Computer Skills
Training
Number of Computer Labs
Teachers' Perceptions of Student Learning from Using Computers
Complexity of Computer Applications Used in Instruction
Teacher Knowledge and Skills
Number of Computers in Each Classroom
Student Learning Rate/Initial Student Rate Learning
To Parents' Perceived Student Learning from Using Computers
Initial Student Learning Rate
Degree of Enrichment and Individualization of Instruction
Information Available for Instruction
To Student Learning Rate
Time Teaching Computer Skills
Required Teacher Preparation Time
Assigned Time in School
Teacher Discretionary Time
Time for Multi-Role Obligations
RTPT/TDT
Class Time Using Computers
To Amount of Software Available for Instruction
Student Computer Skills
To Teachers' Perceptions of the Instructional Suitability of Computers
Student Learning Rate
From Information Available for Instruction
From Administrator Recognition of Teachers for Using Computers

Appendix C: Sector Diagrams


Administrator Sector
Table 1
EffofAICIonRIAICI
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AdmInterestCompInstr
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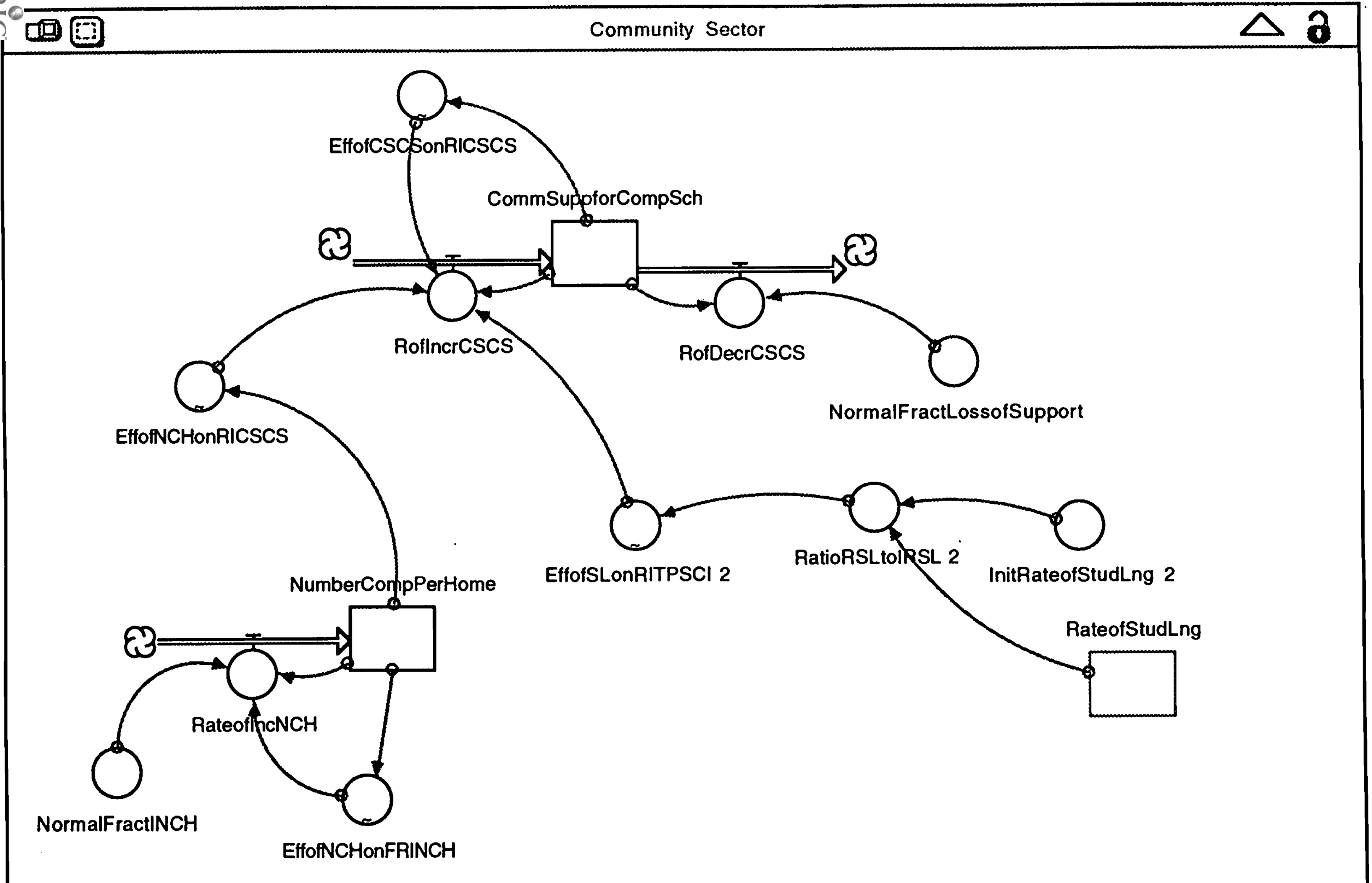
RofLossofAICI
EffofTPSCIonRIAICI
EffofCSCSonRIAICI
EffofCSCSonRLAICI
EffofTPSCIonRLAICI
TchrPercSuitCompInstr
CommSuppforCompSch


Community Sector
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RofDecrCSCS
NormalFractLossofSupport
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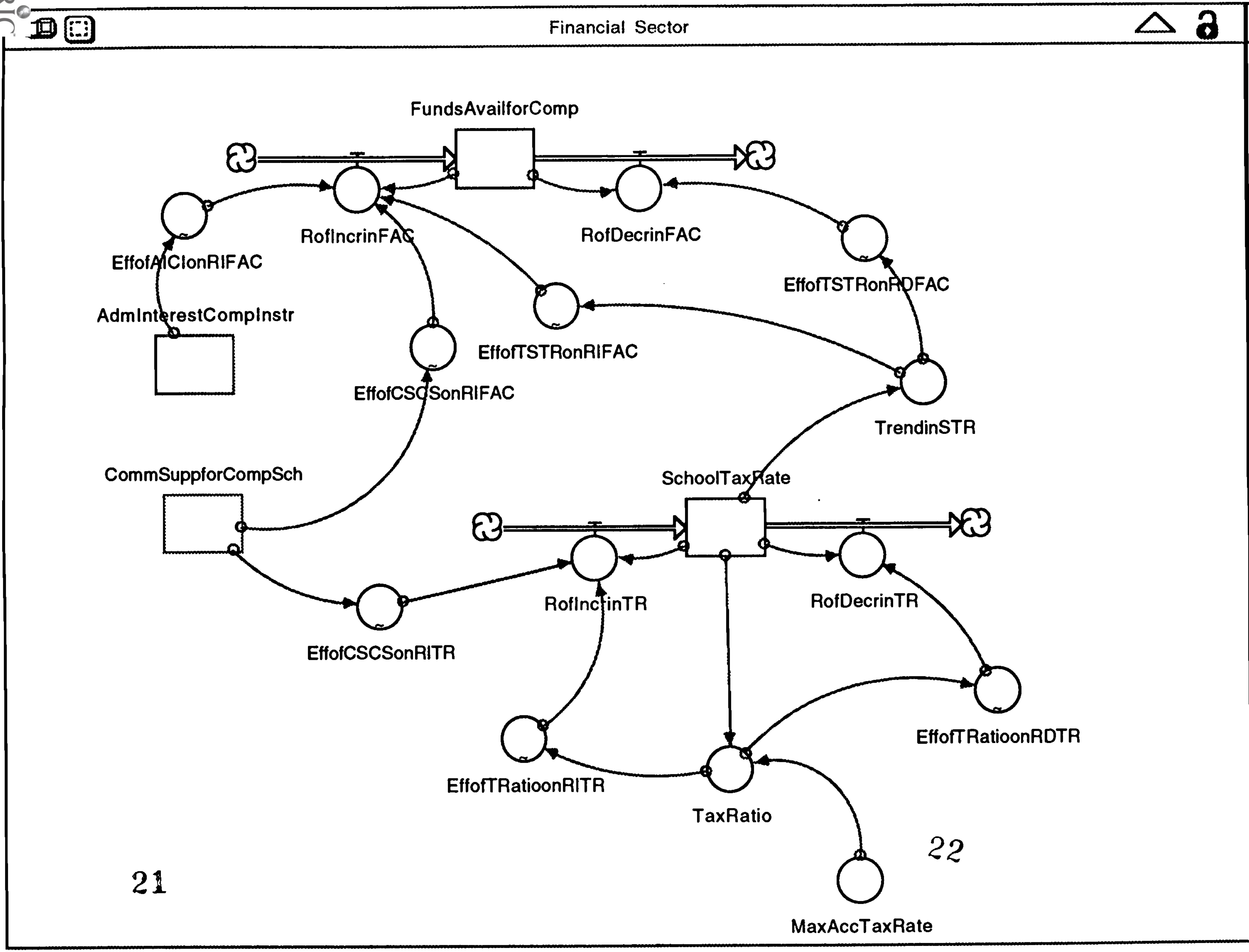
EffofSLonRITPSCI 2
RatioRSLtoIRSL 2
InitRateofStudLng 2
RateofStudLng
NumberCompPerHome
RateofIncNCH
NormalFractINCH
EffofNCHonFRINCH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RofDecrinFAC
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EffofTSTRonRDFAC
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EffofCSCSonRIFAC
TrendinSTR
CommSuppforCompSch
SchoolTaxRate
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RofDecrinTR
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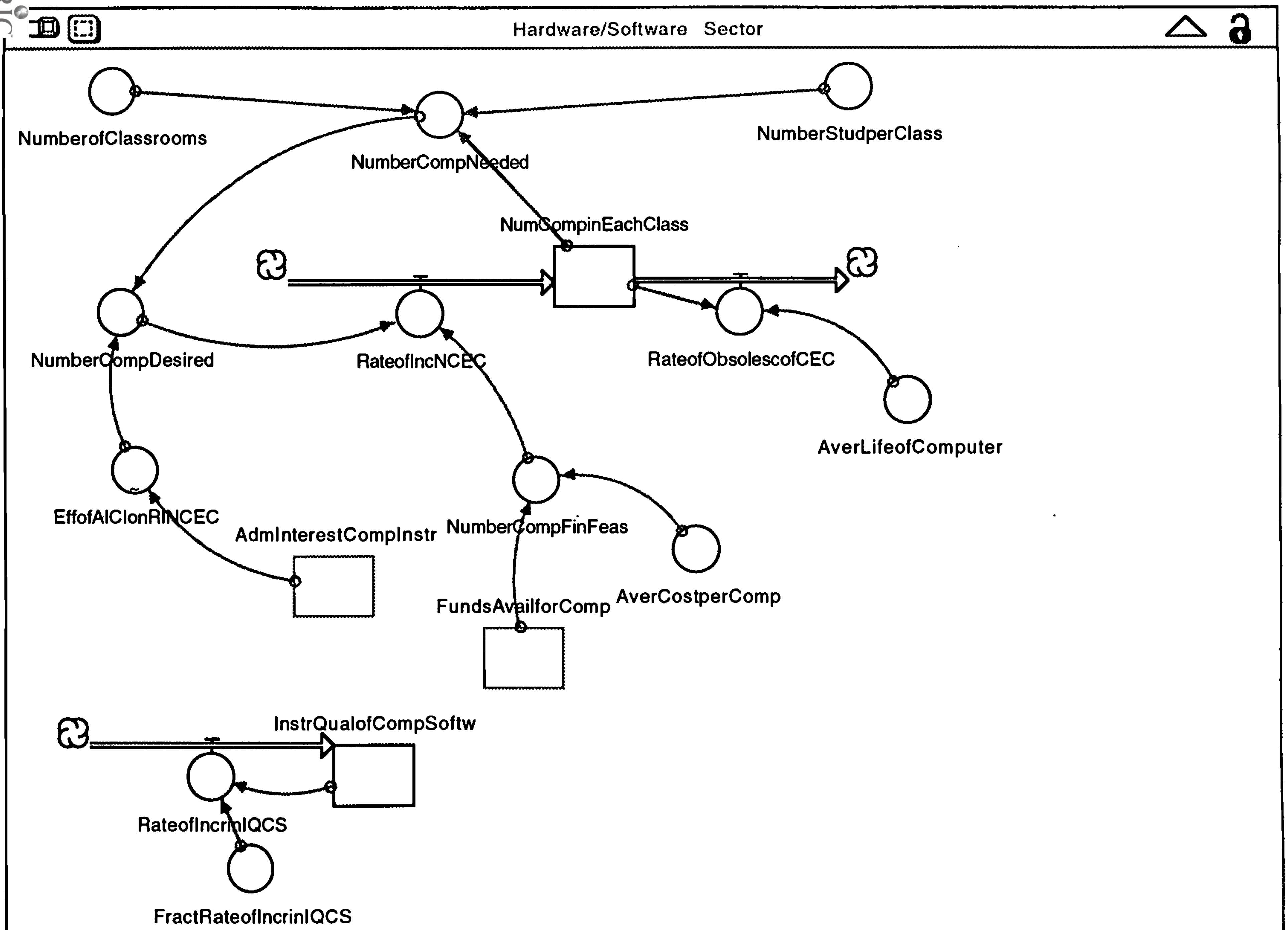
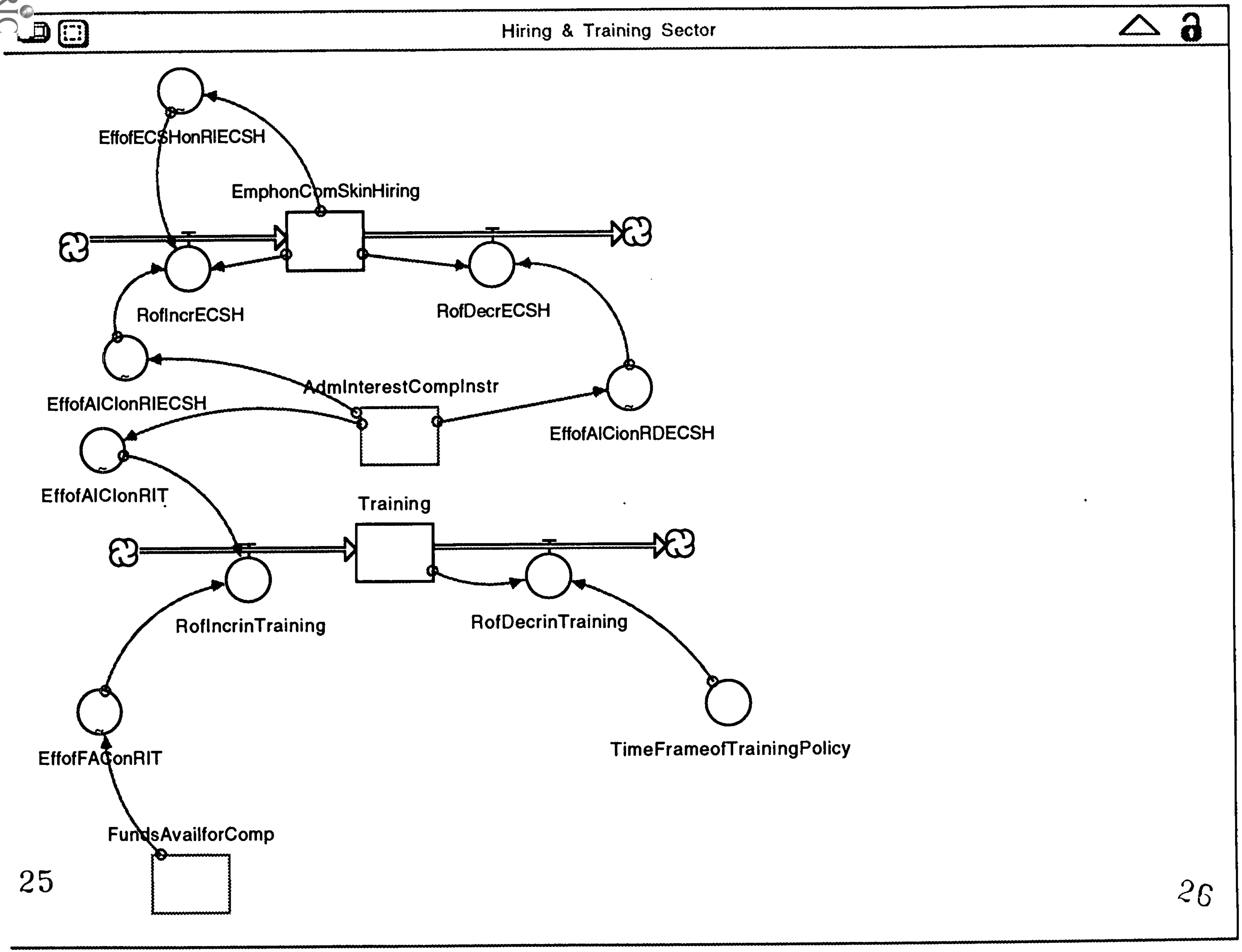
EffofTRatioonRDTR
EffofTRatioonRITR
TaxRatio
MaxAccTaxRate


Hardware/Software Sector
NumberofClassrooms
NumberCompNeeded
NumberStudperClass
NumCompinEachClass
NumberCompDesired
RateofIncNCEC
RateofObsolescofCEC
AverLifeofComputer
EffofAlClonRINCEC
AdmInterestCompInstr
NumberCompFinFeas
AverCostperComp
FundsAvailforComp
InstrQualofCompSoftw
RateofIncrinIQCS
FractRateofIncrinIQCS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RofDecrECSH
EffofAIClonRIECSH
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EffofAICionRDECSH
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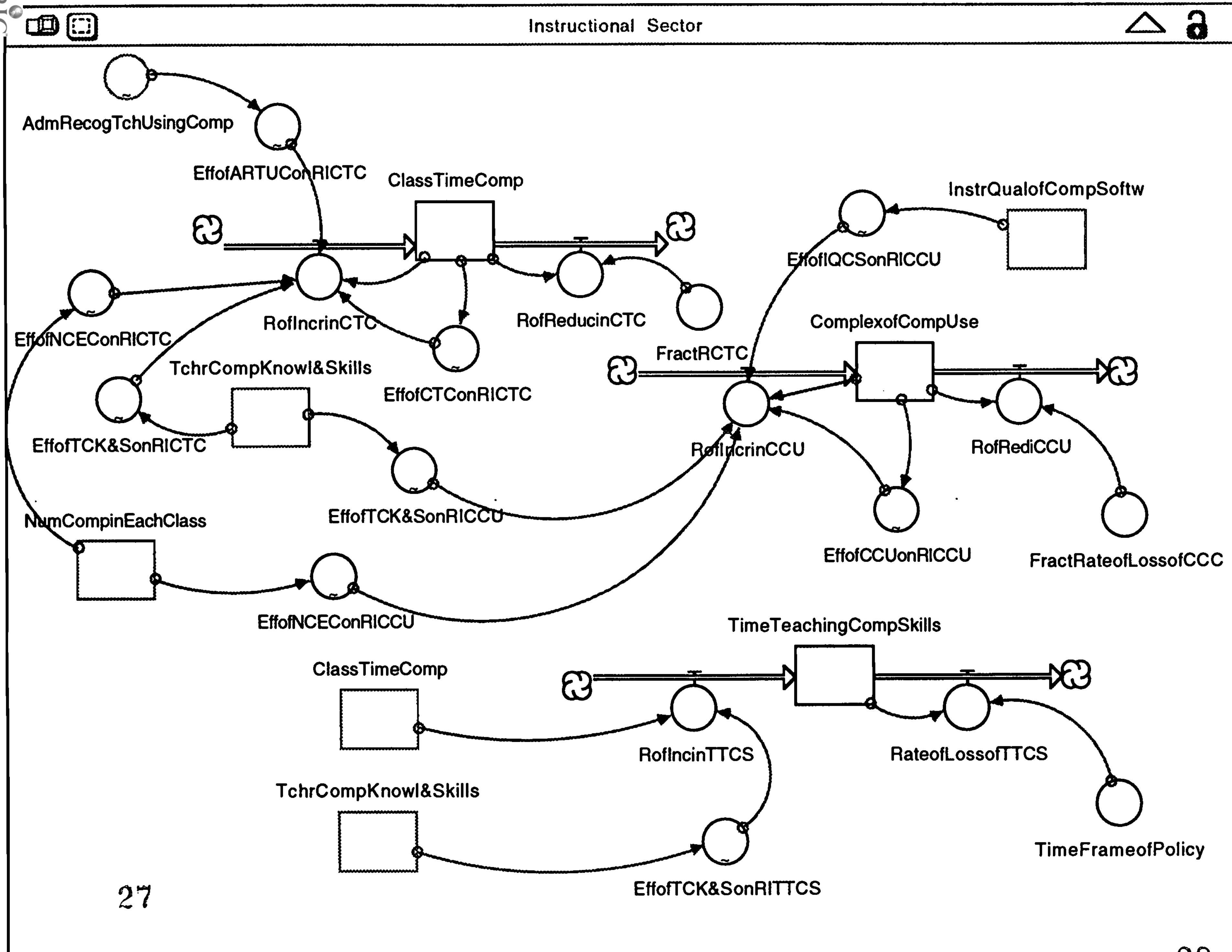
TimeFrameofTrainingPolicy
FundsAvailforComp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EffofNCEConRICTC
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EffofTCK&SonRICTC
EffofCTConRICTC
RofReducinCTC
InstrQualofCompSoftw
EffofIQCSonRICCU
ComplexofCompUse
FractRCTC
RofIncrinCCU
RofRediCCU
EffofTCK&SonRICCU
NumCompinEachClass
EffofCCUonRICCU
FractRateofLossofCCC
EffofNCEConRICCU
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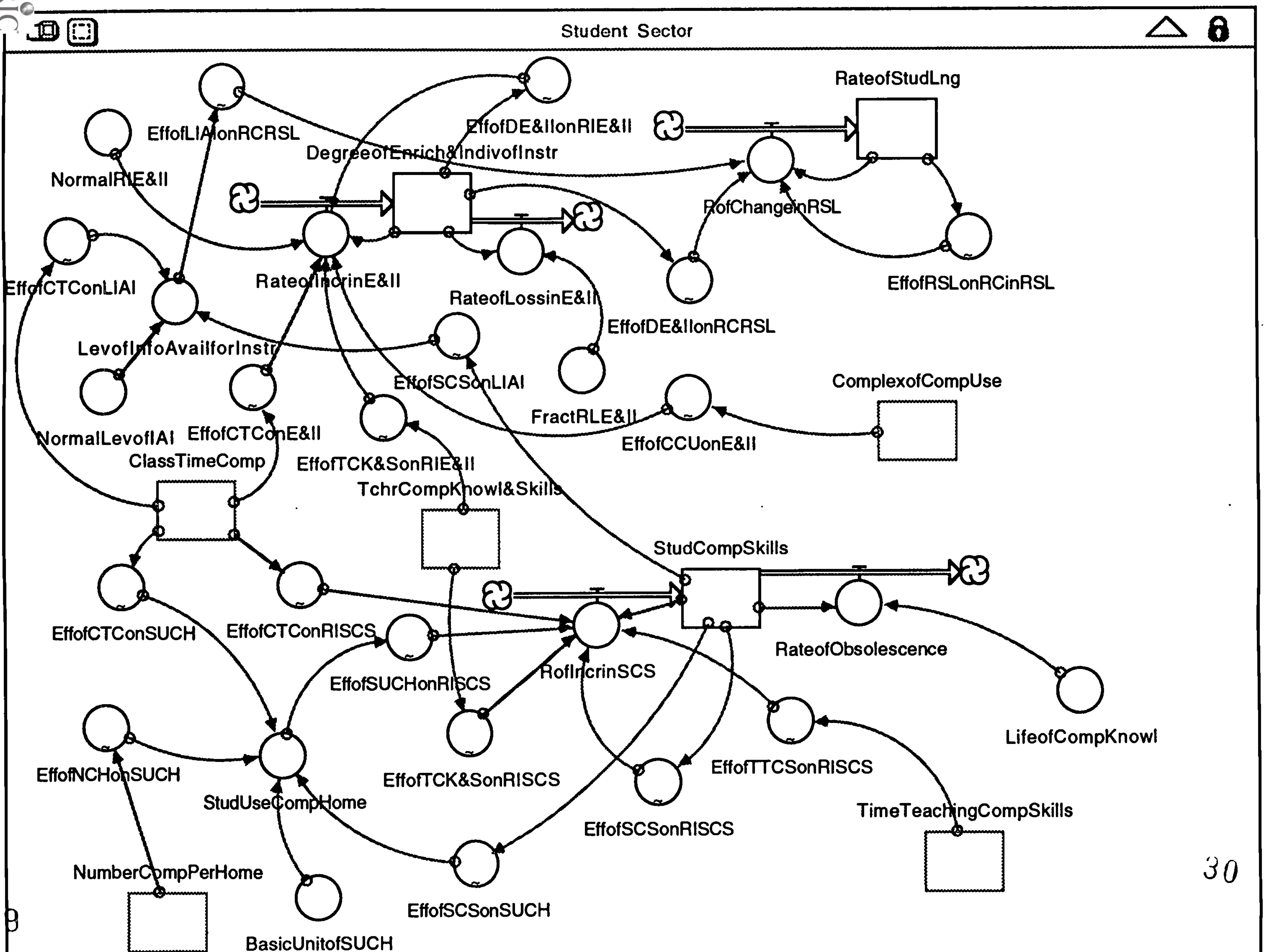
TimeFrameofPolicy

27


Student Sector
RateofStudLng
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EffofDE&IIonRIE&II
NormalRIE&II
DegreeofEnrich&IndivofInstr
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EffofRSLonRCinRSL
EffofCTConLIAI
RateofIncrinE&II
RateofLossinE&II
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LevofInfoAvailforInstr
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NormalLevofIAI
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TchrCompKnowl&Skills
StudCompSkills
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EffofCTConRISCS
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RofIncrinSCS
LifeofCompKnowl
EffofNCHonSUCH
EffofTCK&SonRISCS
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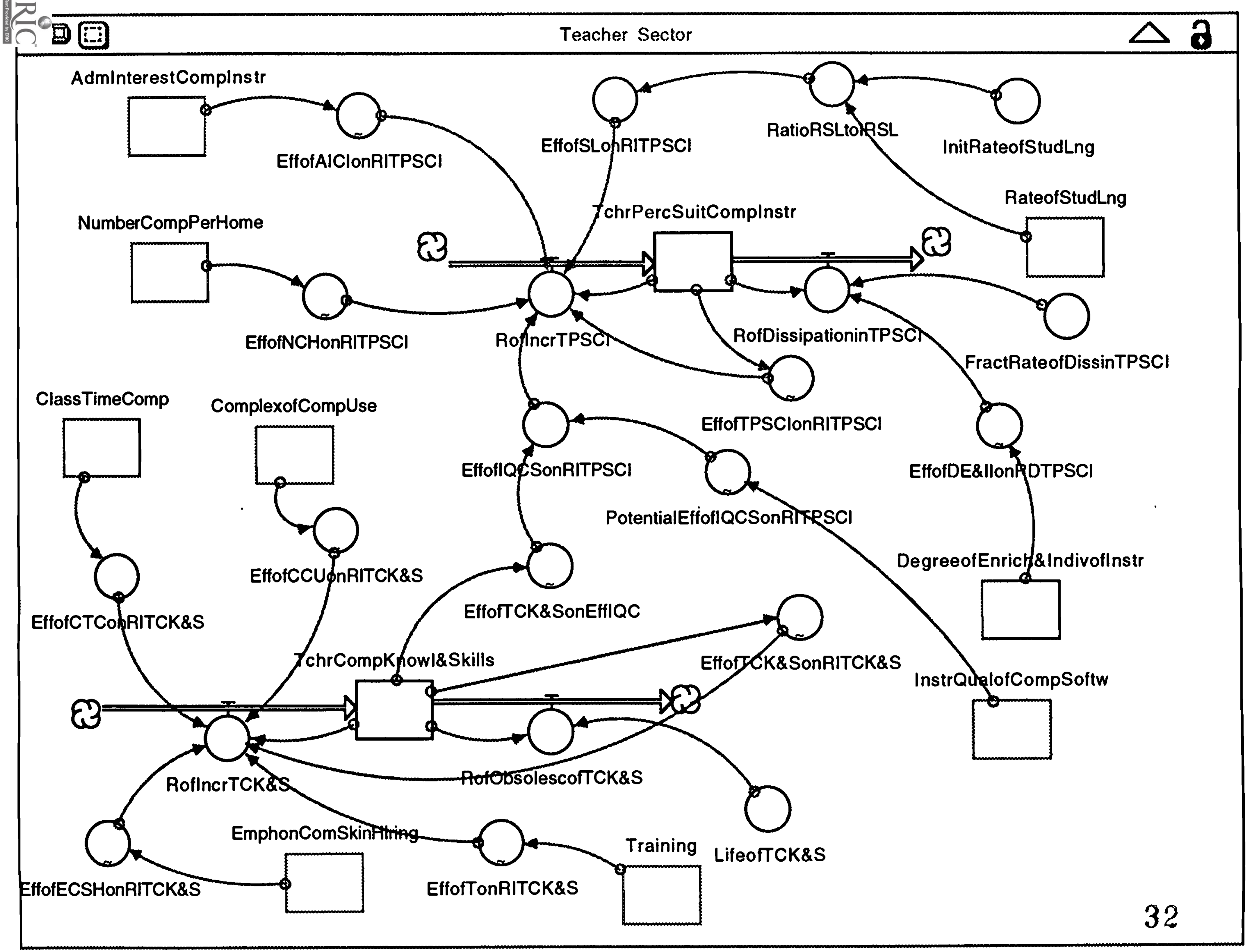
NumberCompPerHome
EffofSCSonSUCH
BasicUnitofSUCH


Teacher Sector
AdmInterestCompInstr
EffofAIClonRITPSCI
EffofSLonRITPSCI
RatioRSLtoIRSL
InitRateofStudLng
RateofStudLng
NumberCompPerHome
TchrPercSuitCompInstr
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RofIncrTPSCI
RofDissipationinTPSCI
FractRateofDissinTPSCI
ClassTimeComp
ComplexofCompUse
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EffofDE&IIonRDTPSCI
PotentialEffofIQCSonRITPSCI
DegreeofEnrich&IndivofInstr
EffofCCUonRITCK&S
EffofTCK&SonEffIQC
EffofCTConRITCK&S
TchrCompKnowl&Skills
EffofTCK&SonRITCK&S
InstrQualofCompSoftw
RofIncrTCK&S
RofObsolescofTCK&S
EmphonComSkinHiring
Training
LifeofTCK&S
EffofECSHonRITCK&S
EffofTonRITCK&S

Appendix D: Equations for the Student and Teacher Sectors

While the paper reports what is still work-in-progress, the causal-loop diagram has been translated into what is called a *system dynamics flow diagram* (Appendix C). This representation of the model incorporates 8 sectors: Administrator; Community; Financial; Hardware/Software; Hiring & Training; Instructional; Student; and Teacher. A first set of equations has been written for each of these sectors; however, the mathematicized model is not yet ready for publication. It is currently in the first stages of testing and refinement. Nevertheless, in order to illustrate the nature of system dynamics modeling, preliminary equations are included below for the student and teacher sectors of the model. These sectors were selected for inclusion with this paper because the students and the teachers are at the heart of the model Student learning is what is ultimately at stake in schools and it is the teachers who finally make the decisions, in policy and in their own behaviors, to use computers to one degree or another in their teaching and to incorporate computer technology into their teaching in more or less complex and integrated ways. It is the teachers who decide on how to use or not use computers to enrich and individualize instruction in their classrooms. The equations are presented and explained below.

Things to Look for in the Equations

System dynamics models represent a particular way of looking at the world, that is a belief that the state of the world is constantly changing and that, therefore, useful theories of problems are developmental theories. As the name "system dynamics" implies, the world is viewed as dynamic in nature, thus developmental. Furthermore, an essential concept of system dynamics thought is that the next stage of development is influenced very strongly by the current state of whatever *problem system* one is examining.[3]

Thus one sees consistently in the equations the interplay between *level* and *rate* equations. The level equations define the changing *state* of the system, in terms of the changing values of its main variables (what are called *state variables*). One might think, for example, of body temperature, blood pressure, heart rate, etc. as state variables of the human biological system, those that physicians monitor as vital signs of health. Similarly, the Federal Reserve Board in the United States monitors key indicators that project the state of the economy, indicators on the basis of which the Fed makes key policy decisions designed to affect subsequent rates of investment, inflation, and so forth.

The level (state) variables in the student sector are "Student Computer Skills" and "Rate of Student Learning." The level variables in the teacher sector are "Teacher

[3] This idea is deeply consistent with the Marxist concept of "sedimentation." That is, historical developments are sedimented in institutional forms which then influence the subsequent development of the political, economic, cultural system (Habermas, 1973).

Computer Knowledge and Skills" and "Teacher Perception of the Suitablility of Computers for Instruction."

Student Sector

Rate of Student Learning (t) = RateofStudLng(t - dt) + (RofChangeinRSL) * dt
Initial Rate of Student Learning = 1

RateofStudLng = Rate of Student Learning

RofChangeinRSL = Rate of Change in the Rate of Student Learning

Rate of Change in the Rate of Student Learning =
(RateofStudLng*(EffofDE&IIonRCRSL+EffofLIAIonRCRSL))*EffofRSLonRCinRSL

EffofDE&IIonRCRSL = Effect of the Degree of Enrichment and Individualization of Instruction on the Rate of Change in the Rate of Student Learning

EffofLIAIonRCRSL = Effect of the Level of Information Available for Instruction on the Rate of Change in the Rate of Student Learning

EffofRSLonRCinRSL = Effect of the Rate of Student Learning on the Rate of Change in the Rate of Student Learning

This formulation depicts changes in the rate of student learning (compared to the normal rate of one grade level per year) as a function of the effects of the enrichment and individualization of instruction and the level of information available for instruction, both of which, it is hypothesized, are affected by the effective use, by knowledgeable and skillful teachers, of computers in instruction. There is a body of research, not conclusive, supporting these claims.

Student Computer Skills (t) = StudCompSkills(t - dt) + (RofIncrinSCS - RateofObsolescence) * dt

INIT StudCompSkills = 1

INIT StudCompSkills = Initial Level of Student Computer Skills

Rate of Increase in Student Computer Skills = (StudCompSkills*(EffofSUCHonRISCS+
EffofCTConRISCS+EffofTTCSonRISCS+EffofTCK&SonRISCS))*EffofSCSonRISCS

StudCompSkills = Student Computer Skills

RofIncrinSCS = Rate of Increase in Student Computer Skills

EffofSUCHonRISCS = Effect of Student Use of Computers at Home on the Rate of Increase in Student Computer Skills

EffofCTConRISCS = Effect of Class Time Using Computers on the Rate of Increase in Student Computer Skills

EffofTTCSonRISCS = Time Teaching Computer Skills on the Rate of Increase in Student Computer Skills

EffofTCK&SonRISCS = Effect of Teacher Computer Knowledge and Skills on the Rate of Increase in Student Computer Skills

EffofSCSonRISCS = Effect of Student Computer Skills on the Rate of Increase in Student Computer Skills

This formulation depicts increases in student computer skills (to a limit of 10) as the additive function of student use of computers in the home, computer time in class, time teaching computer skills, and the computer knowledge and skills of teachers.

Rate of Obsolescence in Student Computer Skills = StudCompSkills/LifeofCompKnowl

StudCompSkills = Student Computer Skills

LifeofCompKnowl = Life of Computer Knowledge

This formulation depicts acquired student computer skills becoming obsolete over a period of 6 years.

BasicUnitofSUCH = 280 days

BasicUnitofSUCH = Basic Unit of Student Use of Computers at Home

FractRLE&II = .025

FractRLE&II = Fractional Rate of Loss of Enrichment and Individualization of Instruction

LevofInfoAvailforInstr = NormalLevofIAI+EffofCTConLIAI+EffofSCSonLIAI

LevofInfoAvailforInstr = Level of Information Available for Instruction

NormalLevofIAI = Normal Level of Information Available for Instruction

EffofCTConLIAI = Effect of Computer Time in Classrooms on the Level of Information Available for Instruction

EffofSCSonLIAI = Effect of Student Computer Skills on the Level of Information Available for Instructions

LifeofCompKnowl = 6

LifeofCompKnowl = Life of Computer Knowledge

NormalLevofIAI = 3.25

NormalLevofIAI = Normal Level of Information Available for Instruction

NormalRIE&II = .025

NormalRIE&II = Normal Enrichment and Individualization of Instruction

StudUseCompHome = BasicUnitofSUCH*(EffofCTConSUCH*EffofNCHonSUCH*EffofSCSonSUCH)

StudUseCompHome = Student Use of Computers at Home

EffofCCUonE&II = GRAPH(ComplexofCompUse)

Effect of Complexity of Computer Use on Enrichment and Individualization of Instruction

ComplexofCompUse = Complexity of Computer Use

(0.00, 0.00), (2.50, 0.005), (5.00, 0.01), (7.50, 0.02), (10.0, 0.025)[4]

EffofCTConE&II = GRAPH(ClassTimeComp)

EffofCTConE&II = Effect of Class Time Using Computers on Enrichment and Individualization of Instruction

(0.00, 0.00), (333, 0.005), (667, 0.01), (1000, 0.025)

EffofCTConLIAI = GRAPH(ClassTimeComp)

EffofCTConLIAI = Effect of Class Time Using Computers on the Level of Information Available for Instruction

(0.00, 0.00), (333, 1.00), (667, 3.00), (1000, 4.00)

EffofCTConRISCS = GRAPH(ClassTimeComp)

EffofCTConRISCS = Effect of Class Time Using Computers on the Rate of Increase in Student Computer Skills

(0.00, 0.00), (250, 0.01), (500, 0.02), (750, 0.04), (1000, 0.05)

EffofCTConSUCH = GRAPH(ClassTimeComp)

EffofCTConSUCH = Effect of Computer Time in Classrooms on Student Use of Computers at Home

(0.00, 1.00), (10.0, 1.00), (20.0, 1.50), (30.0, 1.75), (40.0, 2.00), (50.0, 2.00), (60.0, 1.75), (70.0, 1.50), (80.0, 1.25), (90.0, 1.00), (100, 0.5)

EffofDE&IIonRCRSL = GRAPH(DegreeofEnrich&IndivofInstr)

EffofDE&IIonRCRSL = Effect of the Degree of Enrichment and Individualization of Instruction on the Rate of Change in the Rate of Student Learning

(0.00, 0.9), (2.50, 1.00), (5.00, 1.00), (7.50, 1.20), (10.0, 1.30)

EffofDE&IIonRIE&II = GRAPH(DegreeofEnrich&IndivofInstr)

EffofDE&IIonRIE&II = Effect of the Degree of Enrichment and Individualization of Instruction on the Rate of Increase in Enrichment and Individualization of Instruction

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[4] In each case, the numbers in parentheses are the coordinates of a graph depicting the effect of one variable on another.

(0.00, 1.00), (0.5, 1.00), (1.00, 1.00), (1.50, 1.00), (2.00, 1.00), (2.50, 1.00), (3.00, 1.00), (3.50, 1.00), (4.00, 1.00), (4.50, 1.00), (5.00, 1.00), (5.50, 1.00), (6.00, 1.00), (6.50, 1.00), (7.00, 1.00), (7.50, 1.00), (8.00, 1.00), (8.50, 1.00), (9.00, 0.05), (9.50, 0.01), (10.0, 0.00)

EffofLIAIonRCRSL = GRAPH(LevofInfoAvailforInstr)

EffofLIAIonRCRSL = Effect of the Level of Information Available for Instruction on the Rate of Change in the Rate of Student Learning

(1.00, -0.5), (3.25, 0.00), (5.50, 0.05), (7.75, 0.1), (10.0, 0.2)

EffofNCHonSUCH = GRAPH(NumberCompPerHome)

EffofNCHonSUCH = Effect of the Number of Computers at Home on Student Use of Computers at Home

(0.00, 0.00), (1.00, 0.5), (2.00, 1.00), (3.00, 1.25)

EffofRSLonRCinRSL = GRAPH(RateofStudLng)

EffofRSLonRCinRSL = Effect of the Rate of Student Learning on the Rate of Change in the Rate of Student Learning

(0.00, 1.00), (0.125, 1.00), (0.25, 1.00), (0.375, 1.00), (0.5, 1.00), (0.625, 1.00), (0.75, 1.00), (0.875, 1.00), (1.00, 1.00), (1.12, 1.00), (1.25, 0.5), (1.38, 0.05), (1.50, 0.00)

EffofSCSonLIAI = GRAPH(StudCompSkills)

EffofSCSonLIAI = Effect of Student Computer Skills on the Level of Information Available for Instruction

(0.00, 0.00), (3.33, 1.00), (6.67, 3.00), (10.0, 4.00)

EffofSCSonRISCS = GRAPH(StudCompSkills)

EffofSCSonRISCS = Effect of Stucent Computer Skills on the Rate of Increase in Student Computer Skills

(0.00, 1.00), (0.5, 1.00), (1.00, 1.00), (1.50, 1.00), (2.00, 1.00), (2.50, 1.00), (3.00, 1.00), (3.50, 1.00), (4.00, 1.00), (4.50, 1.00), (5.00, 1.00), (5.50, 1.00), (6.00, 1.00), (6.50, 1.00), (7.00, 1.00), (7.50, 1.00), (8.00, 1.00), (8.50, 1.00), (9.00, 0.05), (9.50, 0.01), (10.0, 0.00)

EffofSCSonSUCH = GRAPH(StudCompSkills)

EffofSCSonSUCH = Effect of Student Computer Skills on Student Use of Computers in the Home

(0.00, 0.00), (2.50, 0.008), (5.00, 0.02), (7.50, 0.04), (10.0, 0.05)

EffofSUCHonRISCS = GRAPH(StudUseCompHome)

EffofSUCHonRISCS = Effect of Student Use of Computers in the Home on the Rate of Increase in Student Computer Skills

(0.00, 0.00), (350, 0.01), (700, 0.02), (1050, 0.04), (1400, 0.05)

EffofTCK&SonRIE&II = GRAPH(TchrCompKnowl&Skills)

EffofTCK&SonRIE&II = Effect of Teacher Computer Knowledge and Skills on the Rate of Increase in Enrichment and Individualization of Instruction

(0.00, 0.00), (2.50, 0.005), (5.00, 0.01), (7.50, 0.02), (10.0, 0.025)

EffofTCK&SonRISCS = GRAPH(TchrCompKnowl&Skills)

EffofTCK&SonRISCS = Effect of Teacher Computer Knowledge and Skills on the Rate of Increase in Student Computer Skills

(0.00, 0.00), (2.50, 0.01), (5.00, 0.02), (7.50, 0.04), (10.0, 0.05)

EffofTTCSonRISCS = GRAPH(TimeTeachingCompSkills)

EffofTTCSonRISCS = Effect of Time Teaching Computer Skills on the Rate of Increase in Student Computer Skills

(0.00, 0.00), (25.0, 0.01), (50.0, 0.02), (75.0, 0.04), (100, 0.05)

Teacher Sector

Teacher Computer Knowledge and Skills(t) = TchrCompKnowl&Skills(t - dt) + (RofIncrTCK&S - RofObsolescofTCK&S) * dt

TchrCompKnowl&Skills = Teacher Computer Knowledge and Skill

INIT TchrCompKnowl&Skills = 20

INIT TchrCompKnowl&Skills = Initial Level of Teacher Computer Knowledge and Skill

Rate of Increase in Teacher Knowledge and Skills = (TchrCompKnowl&Skills*(EffofCTConRITCK&S+EffofECSHonRITCK&S+EffofCCUonRITCK&S+EffofTonRITCK&S))*EffofTCK&SonRITCK&S

TchrCompKnowl&Skills = Teacher Computer Knowledge and Skill

EffofCTConRITCK&S = Effect of Class Time Using Computers on the Rate of Increase in Teacher Computer Knowledge and Skill

EffofECSHonRITCK&S = Effect of the Emphasis on Computer Skills in the Hiring of Teachers on the Rate of Increase in Teacher Computer Knowledge and Skill

EffofCCUonRITCK&S = Effect of the Complexity of Computer Applications Used in Instruction on the Rate of Increase in Teacher Computer Knowledge and Skill

EffofTonRITCK&S = Effect of Training on the Rate of Increase in Teacher Computer Knowledge and Skill

EffofTCK&SonRITCK&S = Effect of Teacher Computer Knowledge and Skill on the Rate of Increase in Teacher Computer Knowledge and Skill

This formulation depicts increases in teacher computer knowledge and skills as an additive function (to a limit of 10) of the effects of class time using computers, the emphasis on computer skills in hiring, the complexity of computer use, and training.

RofObsolescofTCK&S = TchrCompKnowl&Skills/LifeofTCK&S

RofObsolescofTCK&S = Rate of Obsolescence of Teacher Computer Knowledge and Skill

TchrCompKnowl&Skills = Teacher Computer Knowledge and Skill

LifeofTCK&S = Life of eacher Computer Knowledge and Skill

This formulation depicts the acquired computer knowledge and skills of teachers becoming obsolescent over a period of 6 years.

Teacher Perceptions of the Suitability of Computers for Instruction (t) = TchrPercSuitCompInstr(t - dt) + (RofIncrTPSCI - RofDissipationinTPSCI) * dt

TchrPercSuitCompInstr = Teacher Perceptions of the Suitability of Computers for Instruction

INIT TchrPercSuitCompInstr = 1

NIT TchrPercSuitCompInstr = Initial Level of Teacher Perceptions of the Suitability of Computers for Instruction

Rate of Increase in Teacher Perceptions of the Suitability of Computers for Instruction = (TchrPercSuitCompInstr*(EffofAICIonRITPSCI+EffofIQCSonRITPSCI+EffofNCHonRITPSCI+EffofSLon RITPSCI))*EffofTPSCIonRITPSCI

TchrPercSuitCompInstr = Teacher Perceptions of the Suitability of Computers for Instruction

EffofAICIonRITPSCI = Effect of Administrator Interest in Computers for Instruction on the Rate of Increase in Teacher Perceptions of the Suitability of Computers for Instruction

This formulation depicts increases in teachers' perceptions of the suitability of computers for instruction (to a limit of 10) as an additive function of the effects of administrator interest in computers for instruction, the instructional quality of computer software, the average number of computers in students' homes, and the effects of improvements in student learning attributed to using computers in instruction.

Rate of Dissipation in Teacher Perceptions of the Suitability of Computers for Instruction = TchrPercSuitCompInstr*FractRateofDissinTPSCI*EffofDE&IIonRDTPSCI

TchrPercSuitCompInstr = Teacher Perceptions of the Suitability of Computers for Instruction

FractRateofDissinTPSCI = Fractional Rate of Dissipation in Teacher Perceptions of the Suitability of Computers for Instruction

EffofDE&IIonRDTPSCI = Effect of Degree of Enrichment and Individualization of Instruction on the Rate of Dissipation in Teacher Perceptions of the Suitability of Computers for Instruction

This formulation depicts an unexplained loss in teachers' perceived suitability of computers for instruction of five percent which is then influenced variably by the effects of the degree of enrichment and individualization of instruction (which increases teachers' workloads and diminishes progressively their belief in the suitability of computers for instruction, at least to the extent that using computers in instruction is viewed thusly as contributing to increasing their workloads beyond acceptable levels).

EffofIQCSonRITPSCI = PotentialEffofIQCSonRITPSCI*EffofTCK&SonEffEQC

EffofIQCSonRITPSCI = Effect of the Instructional Quality of Computer Software on the Rate of Increase of Teacher Perceptions of the Suitability of Computers for Instruction

PotentialEffofIQCSonRITPSCI = Potential Effect of the Instructional Quality of Computer Software on the Rate of Increase in Teacher Perceptions of the Suitability of Computers for Instruction

EffofTCK&SonEffIQC = Effect of Teacher Computer Knowledge and Skill on the Effect of the Instructional Quality of Computer Software

FractRateofDissinTPSCI = .05

FractRateofDissinTPSCI Fractional Rate of Dissipation in Teacher Perceptions of the Suitability of Computers for Instruction

InitRateofStudLng = 1

InitRateofStudLng = Initial Rate of Student Learning

LifeofTCK&S = 6

LifeofTCK&S = Life of Teacher Computer Knowledge and Skills

RatioRSLtoIRSL = RateofStudLng/InitRateofStudLng

RatioRSLtoIRSL = Ratio of the Rate of Student Learning to the Initial Rate of Student Learning

EffofAICIonRITPSCI = GRAPH(AdmInterestCompInstr)

Effect of Administrator Interest in Computers for Instruction on the Rate of Increase of Teacher Perceptions of the Suitability of Computers for Instruction

AdmInterestCompInstr = Administrator Interest in Computers for Instruction

(0.00, 0.00), (1.00, 0.00), (2.00, 0.00), (3.00, 0.0025), (4.00, 0.005), (5.00, 0.0075), (6.00, 0.01), (7.00, 0.0125), (8.00, 0.015), (9.00, 0.02), (10.0, 0.025)

EffofCCUonRITCK&S = GRAPH(ComplexofCompUse)

EffofCCUonRITCK&S = Effect of the Complexity of Computer Use on the Rate of Increase in Teacher Computer Knowledge and Skills

(0.00, 0.00), (1.00, 0.02), (2.00, 0.03), (3.00, 0.05), (4.00, 0.075), (5.00, 0.1), (6.00, 0.15), (7.00, 0.2), (8.00, 0.25), (9.00, 0.3), (10.0, 0.5)

EffofCTConRITCK&S = GRAPH(ClassTimeComp)

EffofCTConRITCK&S = Effect of Class Time Using Computers on the Rate of Increase in Teacher Computer Knowledge and Skills

(0.00, 0.00), (200, 0.1), (400, 0.2), (600, 0.2), (800, 0.2), (1000, 0.2)

EffofECSHonRITCK&S = GRAPH(EmphonComSkinHiring)

EffofECSHonRITCK&S = Effect of the Emphasis on Computer Skills in Hiring Teachers on the Rate of Increase in Teacher Computer Knowledge and Skills

(0.00, 0.00), (2.50, 0.02), (5.00, 0.05), (7.50, 0.1), (10.0, 0.2)

EffofNCHonRITPSCI = GRAPH(NumberCompPerHome)

EffofNCHonRITPSCI = Effect of the Number of Computers in the Home on the Rate of Increase of Teacher Perceptions of the Suitability of Computers for Instruction

(0.00, 0.00), (1.00, 0.00), (2.00, 0.00), (3.00, 0.003), (4.00, 0.005), (5.00, 0.007), (6.00, 0.01), (7.00, 0.013), (8.00, 0.015), (9.00, 0.02), (10.0, 0.025)

EffofSLonRITPSCI = GRAPH(RatioRSLtoIRSL)

EffofSLonRITPSCI = Effect of Student Learning on the Rate of Increase of Teacher Perceptions of the Suitability of Computers for Instruction

(0.8, -0.25), (0.9, -0.15), (1.00, 0.00), (1.10, 0.02), (1.20, 0.05), (1.30, 0.1), (1.40, 0.15), (1.50, 0.2)

EffofTCK&SonEffEQC = GRAPH(TchrCompKnowl&Skills)

EffofTCK&SonEffIQC = Effect of Teacher Computer Knowledge and Skills on the Effect of the Instructional Quality of Computer Software

(0.00, 0.00), (2.50, 0.5), (5.00, 0.75), (7.50, 1.00), (10.0, 1.25)

EffofTCK&SonRITCK&S = GRAPH(TchrCompKnowl&Skills)

EffofTCK&SonRITCK&S = Effect of Teacher Computer Knowledge and Skills on the Rate of Increase in Teacher Computer Knowledge and Skills

(0.00, 1.00), (1.00, 1.00), (2.00, 1.00), (3.00, 1.00), (4.00, 1.00), (5.00, 1.00), (6.00, 1.00), (7.00, 1.00), (8.00, 0.5), (9.00, 0.02), (10.0, 0.00)

EffofTonRITCK&S = GRAPH(Training)

EffofTonRITCK&S = Effect of Training on the Rate of Increase in Teacher Computer Knowledge and Skills

(0.00, 0.00), (20.0, 0.05), (40.0, 0.1), (60.0, 0.2), (80.0, 0.3), (100, 0.4)

EffofTPSCIonRITPSCI = GRAPH(TchrPercSuitCompInstr)

EffofTPSCIonRITPSCI = Effect of Teacher Perceptions of the Suitability of Computers for Instruction on the Rate of Increase in Teacher Perceptions of the Suitability of Computers for Instruction

(0.00, 1.00), (0.5, 1.00), (1.00, 1.00), (1.50, 1.00), (2.00, 1.00), (2.50, 1.00), (3.00, 1.00), (3.50, 1.00), (4.00, 1.00), (4.50, 1.00), (5.00, 1.00), (5.50, 1.00), (6.00, 1.00), (6.50, 1.00), (7.00, 1.00), (7.50, 1.00), (8.00, 1.00), (8.50, 1.00), (9.00, 0.5), (9.50, 0.01), (10.0, 0.00)

PotentialEffofIQCSonRITPSCI = GRAPH(InstrQualofCompSoftw)

PotentialEffofIQCSonRITPSCI = Potential Effect of the Instructional Quality of Computer Software on the Rate of Increase in Teacher Perceptions of the Suitability of Computers for Instruction

(0.00, 0.00), (1.00, 0.00), (2.00, 0.00), (3.00, 0.003), (4.00, 0.005), (5.00, 0.007), (6.00, 0.01), (7.00, 0.013), (8.00, 0.015), (9.00, 0.02), (10.0, 0.025)

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