Modeling E-Material Supply Chain

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Abstract

This paper looks at the issue of E-Learning provision from a supply chain perspective. It tries to apply some of the commonly used supply chain practices like Inventory Management, Cost reduction and Demand Forecasting to the content assets created by e-learning organizations. In this context the study presents a system dynamics framework to model the Information Technology Institute (ITI) e-material supply chain as a case study of digital product supply chain. This e-material supply chain serves a foundation of providing e-learning programs. The aim of this study is to understand the dynamic structure of this e-material supply chain and hence suggest and evaluate possible policies to enhance its current performance. The first section is an overview of the e-material supply chain. The second defines the problem with the ITI e-material supply chain. The third section is for literature review. The fourth describes the model and the fifth discuss the model behavior. A list of suggested policies is evaluated to increase the e-material supply chain performance and decrease the associated costs in the sixth section. In the last section we conclude.

Keywords: E-learning, E-Material, Supply Chain Management, System Dynamics, E-Material Supply Chain, Egypt.

1. Overview of the e-material supply chain

A supply chain of a certain product or a service essentially has three main parts, the supply, manufacturing and distribution: The **supply** side concentrates on how, where from and when raw materials are procured and supplied to manufacturing. **Manufacturing** converts these raw materials to finished products and **Distribution** ensures that these finished products reach the final customers through a network of distributors, warehouses and retailers.

The e-material provision for e-learning purposes encompasses the manufacturing and distribution of e-courses and services and the technologies that underpin these activities. This paper looks at the issue of e-material provision from a supply chain perspective. It tries to apply some of the commonly used supply chain practices like Inventory Management, Cost reduction and Demand Forecasting to the content assets created by e-learning organizations.

In the e-material supply chain as illustrated in figure 1, the supply side matches the process of writing material that could be published online for remote teaching and revising it to be sure that it meets the accepted quality level. The process of transforming this raw material into an e-material that could be published on an e-learning tool and the online instruction of this material matches the manufacturing side of the supply chain. Distribution in the digital services and products and specially e-learning is usually done through online catalogues (e-catalogue) that are found on the online stores of the e-learning websites. In an e-catalogue students browse courses offered to choose from which most suit there needs. They buy access to the e-material published on the e-learning management system till they graduate.

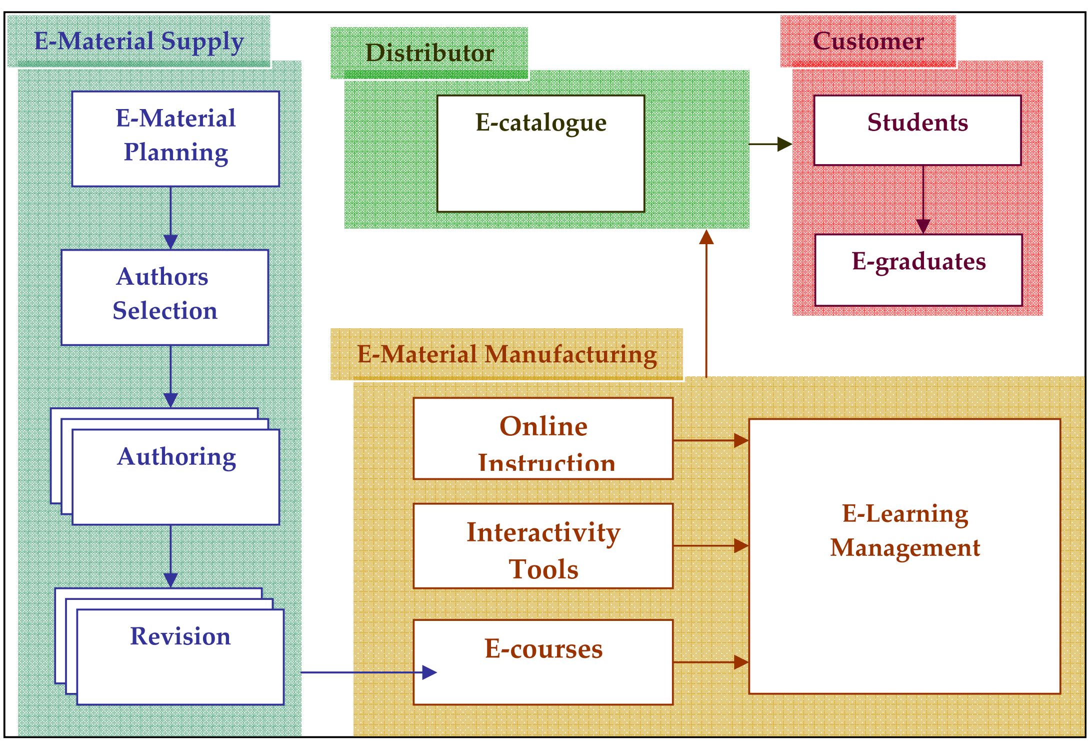

Figure 1, E-material supply chain

The very essence of Supply Chain Management is effective information and material flow throughout a network of customers and suppliers. Supply chain management involves coordinating and integrating these flows. The product flow includes the movement of goods from a supplier to a customer, as well as any customer returns or service needs. The information flow involves transmitting orders and updating the status of delivery. The financial flow consists of credit terms, payment schedules, and consignment and title ownership arrangements. Figure 2 shows how material, funds and information flows across the e-material supply chain. The red arrows represent the material flow, blue arrows represent the flow of information and the black arrows shows the flow of funds across the supply chain.

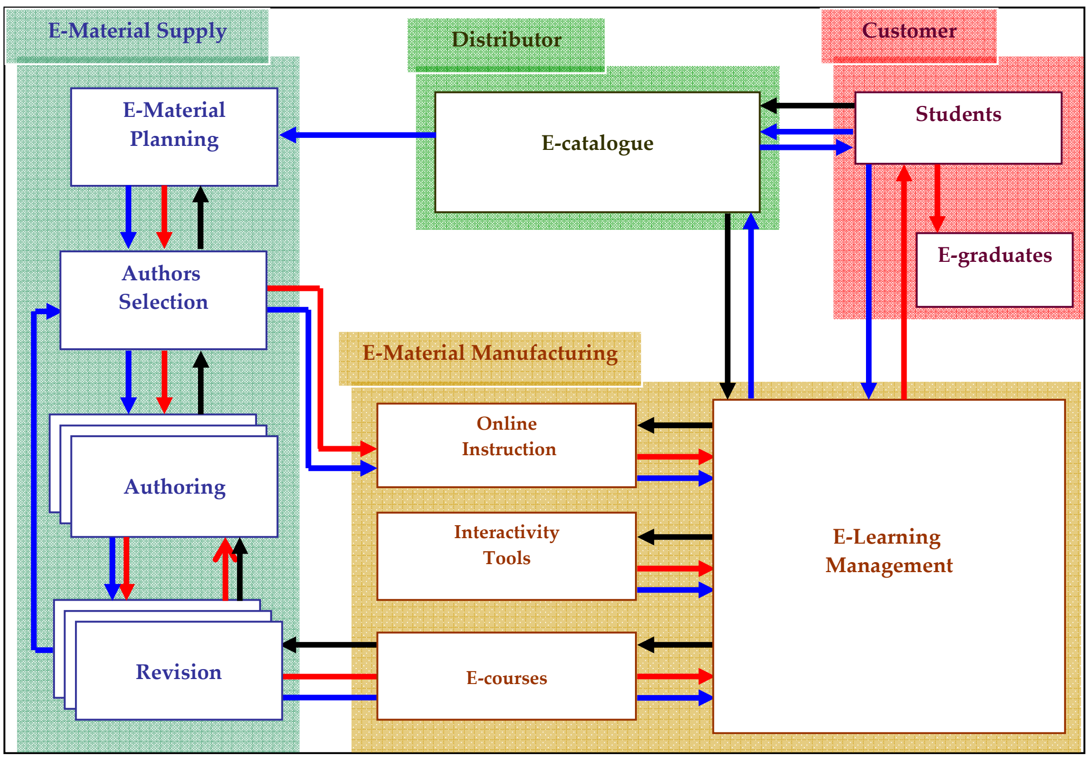

Figure 2, E-material supply chain information, material and funds flows

Information flow (blue arrows) starts by planning the online curriculum that is demanded by e-students. The information continues flowing along the authoring and material revision and is passed to the manufacturing side, then settle on the e-catalogue. Students' start to gather information about online material and buy access to e-material. Physical product or Material (red arrows) passes by three phases. In phase one selected instructors are asked to write the courses of the online curriculum. The second phase is concerned by transforming the authored material into a published material and assembling it with online instruction and interactivity tools. And finally the material is distributed over a website to be available for students to logon and study. Costs (black arrows) accumulate each step in the supply chain and funds are raised by students' registration and payment to the e-learning services they acquire.

Effectively managing these flows can impact virtually all e-material supply chain, leading to profitable policies for continuous improvements in areas such as data accuracy, improving material quality, reducing lead times and reductions in operational complexity. Other benefits include:

- Improved delivery performance—quicker customer response and fulfillment rates especially in the field of IT which is changing very rapidly
- Greater productivity and lower costs
- Reduced inventory throughout the chain
- Improved forecasting precision of demand
- Enhanced inter-operational communications and cooperation
- More reliable financial information.

2. Problem definition

2.1. The History of the Information Technology Institute

The Information Technology Institute (ITI) is a national institute established in 1993 by the Information and Decision Support Center (IDSC) under the auspice of the Egyptian Cabinet. It provides specialized software development programs to fresh graduates, as well as professional training programs and IT courses for the Egyptian Government, ministries, and local decision support centers. In 1996, ITI launched its second branch in Alexandria to facilitate the widespread of Information Technology throughout the country, and expand the outreach of ITI. In April 2005, Prime Minister Dr. Ahmed Nazif transferred the dependency of Information Technology Institute (ITI) to Ministry of Communications and Information Technology (MCIT). ITI has a board of trustees which is headed by His Excellency the Minister of Communications and Information Technology, Dr. Tarek Kamel. The board members include experts from the MCIT, academia, and information and telecommunication companies.

Over the past 12 years, ITI has supplied the Local, Regional and International markets with highly-trained professionals in various IT domains, following a 9-month intensive training program. Those graduates make up the backbone of the IT workforce in Egypt. In addition, ITI through its governmental training program has trained 50 thousands Governmental Employees and supervised the training of Over 400 thousands in Governorates' Training Centers.

2.2. Overview of the ITI's E-learning Program (VITI)

Due to the fact that the number of applicants exceed the institute's available resources and in order to satisfy the needs of the working class who wish to learn after working hours, ITI wanted to publish its courses on the Internet to reach more students at their leisure time and place limitation; helping in this respect to spread software technology to all those in demand of such courses. The thought materialized early 1998 in one of the graduation projects of the ninth intake at the ITI by four ITIans, who made the first prototype for online teaching project and called it "Global Campus". There were lots of trials afterwards and by the end of 1999 this project reappeared again headed by one of the members of the Global Campus project (which is also one of the authors of this paper) and finally delivered the first course.

In 2001, the project launched a more enhanced website version which included 20 online courses in Arabic and English for free. This was mainly to increase the awareness of Arabs about e-learning. In this year also the ITI e-learning website was chosen as one of the best 20 international projects on e-learning in Stockholm Challenge Award 2001. The most important criterion in this international competition is how the project benefits people, the society and the environment.

The first online diploma from the ITI was offered commercially by December 2003, and the online learning process started by 2004. This online diploma was offered through the "Virtual ITI portal" (also called VITI) (http://www.viti.gov.eg). The program offers state-of-the-art training in the software development field. The strategy of the program is to be demand-oriented utilizing the current technology trends in the international software industry and conforming to the world-class professional standards. It aims at producing professional information technology specialists ready to contribute to the realm of information engineering and professional software development.
The online Program consists of the following three modules:

1. The Foundation Module – Fundamentals.
2. The Focus Module – Specialization.
3. The Performance Module – Project.

The online Focus Module branches into 3 different specializations, each with a unique set of training courses where students have to choose one from the following tracks:

- System Development (SD).
- Java.
- Multimedia (MM).

This current phase of the e-learning program had many problems concerning internet bandwidth and students' culture that resist self training and are still seeking instructional learning. These problems were common for any e-learning program, but the real problems that faced the program was a lot of critiques concerning the type of material offered, quality of the material, demand for more courses and demand for newer versions of the existing online courses. These problems were mainly coming from the lack of experience in a new field like e-learning that lead to inadequate performance of the production processes and long production times. Production time for an electronic course (e-course) takes more than 6 months from the time an instructor starts to write the course material till the time it is deployed on the VITI portal to be distributed to online students. This period is too long and contains 5 different production sub-processes; each is dependent on the pervious process and requires different skills in the assigned labor. As a new experience for ITI instructors to write online material, the written material contains many technical errors and linguistic errors, which required adding two processes of technical and language revision to be performed. For transferring this written material into an electronic form, two extra processes are required; developing the written material into an electronic form and testing the usability and functionality of the courses. In addition to adding a number of e-learning interactivity tools to overcome the quality of the e-material offered. The bright side of these modifications was that the produced e-material reached the fifth level of Guerra scale. The scale outlines the range of online content that we can use. It describes an increasingly interactive user experience using a one-to-ten scale, in which "one" involves the common experience of simply reading text on a screen and "ten" represents a virtual reality scenario.

2.3. Main Problems

As an early adopter to e-learning programs, the Institute took the risk of adopting an e-learning initiative in Egypt at a time when the number of internet users was only around 120,000 back at 1998. Figure 3 shows the massive increase in the numbers of internet users in Egypt over the past five years. There was a debate on whether it was best for the ITI to proceed with the e-learning program or close it, this debate was not only at the beginning of the project but lasted a couple of years later. But its strong vision and belief of the importance of introducing e-learning to the Egyptian training market made the ITI persist on keeping the program till this day.

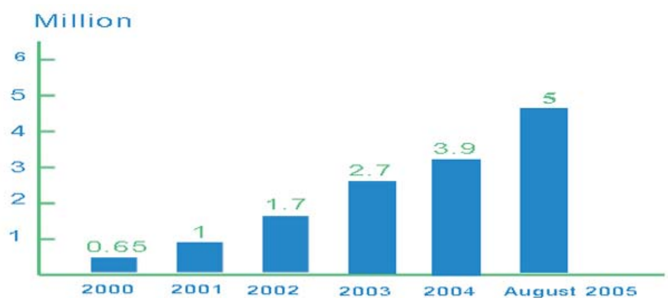

Figure 3, Internet users in Egypt,
Source: The Egyptian Ministry of Communication and Information Technology (MCIT) website.

From its very beginning there were a lot of problems that faced this program like problems in quality and delivery time of the electronic material supplied, high software development cost, failure to meet development schedules with the required quality, etc. These problems accumulated and grown bigger over the years as a result of the following obstacles:

1. ***Lack of past experience in e-learning:*** not just in Egypt but in the global market.
2. As a new concept and not yet known in most of the countries, there was ***no demand for e-learning*** in Egypt. The ITI had to initiate a demand on e-learning.
3. Even if the ITI was to spread the knowledge of e-learning among Egyptians, there was ***demand uncertainty*** on who would prefer to shift from traditional teaching to remote teaching ***(culture shift)***.
4. ***Lack of supply chain management practices***: the ITI did not apply the concepts of supply chain management on its processes of providing e-learning to the Egyptian training market.

5. ***Information and Communication Technology (ICT)*** infrastructure was not yet mature back then.

As for obstacle 5, it has been eliminated by the establishment of the Ministry of Information and Communication (MCIT) at 2001 that created noticeable improvement in the internet society in Egypt because of the telecommunication infrastructure expansions and the ministry's initiatives in offering computers in low prices and the internet freely for the Egyptians.

Obstacles 1 and 2 had their highest effects in the earlier years of the e-learning program, but as the first version was disseminated in 2001 for free, a lot of Internet users logged on the site from different countries and got used to the idea of online education. The effects of these two obstacles nearly disappeared when the program got its first international recognition and was chosen as one of the best 20 international projects on e-learning in Stockholm Challenge Award 2001.

Yet there are demand uncertainty and lack of supply chain practices obstacles to be conquered. Supply chain management is a technique that considers all aspects that lets an organization gets the right goods and services to the place they're needed at the right time, in the proper quantity and at an acceptable cost. Efficiently managing this process involves overseeing relationships with suppliers and customers, controlling inventory, forecasting demand and getting constant feedback on what's happening at every link in the chain.

In real world, things are not that easy as "Choose a policy, and then apply it" or "Apply this policy, it is a successful one". Consequences of applying a policy (that seemed the right one and turned to be not) could cost organizations million of pounds. This calls for further work in the step of designing policies and evaluating them for successful supply chain implementation.

A system dynamic method is also suggested. Using the system dynamics method, we should be able to understand the nature of the complexity governing the real world; i.e. how structure drives behavior and how the resulting behavior causes shifts in structural dominance in complex nonlinear, dynamics systems. This would then serve as a foundation for policy design and strategy development and, thus for the management of complex, dynamic ITI e-learning supply chain successfully.

As the ITI e-material supply chain suggested is a good example to research as supply, manufacturing and distribution along with students' management are for the most part processed and developed at the ITI which make it easier to study and thus manage. The purpose of this study is to understand the dynamics and the complexity of the e-learning supply chain management by taking the electronic material (e-material) supply chain at ITI as an example. The emphasis is on how might ITI benefit from system dynamic techniques in understanding its e-material supply chain and hence implement more powerful corrective policies concerning the overall performance of its e-material supply chain.

The objective of this research is to:

- Study the e-material supply chain at the ITI and evaluate possible policies to enhance its performance.

3. Literature Review

Historically the usage of system dynamics to analyze and explain issues evolving around supply chain management started by Forrester (1961). He developed a continuous time mathematical model of the dynamic production and distribution process. It has been shown that the factory production rate often fluctuates more widely than the fluctuation in the retail consumption rate. This phenomena is called the bullwhip effect.

Huang et al. (2003) provides a rich review on supply chain dynamics literature, investigating the impacts of information sharing and supply chain structure. Riddalls and Bennett (2002) have modeled the aggregated production-inventory system by assuming pure production delays. The dynamics was also evaluated on supply chains by cascading such production inventory systems. Tomlin (1999) has analyzed capacity investments in single-product supply chains in which the participants make investments to maximize their individual expected profits. The solution approaches to capacity decisions in multiple products; multiple stage supply chain is also described. But the method works under demand patterns that assure an upper bound stock out. Helo (2000) deals with demand magnification, tradeoff between capacity utilization and lead times under capacity constraints and concludes that capacity utilization is an important factor and can be used as a substitute for inventory.

Akkermans and Dellaert (2005) describe the evolution of the research into supply chains by using the same distinction that Holweg and Disney (2005) made in their description of the evolving frontiers of the bullwhip problem. They distinguish three methodological domains in supply chain research: (1) the discrete time approach; (2) the continuous time approach; and (3) the control theory approach, also known as the frequency domain approach.

The discrete time approach is the most popular approach in the Production and Inventory Control environment, assuming periodic (daily, weekly) decisions on production and order quantities, and expressing lead-times, capacity and demand also in relation to the duration of the decision periods. Within the continuous time approach, Jay Forrester was the founding father of the system dynamics approach, which was originally applied in supply chain dynamics problems (Forrester 1958, 1961). In these models the states of the supply chain system (inventories, orders in pipeline, work in progress) are monitored continuously and also decisions are taken continuously. Different from the discrete time approach, capacity is explicitly modeled in many applications (Mass 1975), as well as learning effects and human perception. Control theory may assume either continuous or discrete time and typically uses linear transfer functions and transformations to relate the system output to the system input. Its contribution is usually aiming at production smoothing.

The three approaches are used for quantitative analysis of supply chains, but the analysis often differs with respect to assumptions and also with respect to the goals to be achieved. This paper follows the continuous time approach as system dynamics approach can easily incorporate all kinds of elements to re-engineer the supply chain (Sterman 2000, p. 741), and is thus not only successful in explaining supply chain behavior, but also in providing valuable insights in the process improvement phase. Table 2.1 -- which was provided by Angerhofer (2000) -- shows the various techniques and methods applied in different research areas, whether in theory building, or problem solving, or improving the modeling approach.

Category / *Research Area*	**Research:** *Modeling for Theory Building*	**Practice:** *Modeling for Problem Solving*	**Putting Research into Practice:** *Improving the Modeling Approach*
Inventory Management	(b)	(b)(c)	
Demand Amplification	(b)	(b)	
Supply Chain Re-Engineering	(a)(b)(c)	(a)(b)(c)	(a)(b)(c)
Supply Chain Design	(a)	(a)(b)(c)	(a)(b)(c)
International Supply Chain Management	(a)	(a)(b)(c)	(a)(b)(c)(d)

Key to Table 1: Techniques and Methods applied
(a) Causal Loop Diagramming
(b) Continuous simulation
(c) OR techniques
(d) Discrete simulation

Table 1, Taxonomy of Research and Development in Modeling Supply Chain Management

This study proposes to expand the literature on dynamic simulation of supply chain analysis and design to include digital products. Our problem of exploring the e-material supply chain and designing structure to minimize the supply chain costs falls under the research areas of Inventory Management and Supply Chain Design.

4. Model overview

4.1 The model subsystems

In this study a simulation model for the e-material supply chain has been formulated based on Sterman's (2000) generic model for demonstrating supply chain dynamics. The main concern of this model is to explore effective policies that could enhance the e-material supply chain performance and reduce the associated costs. For that reason the model includes a group of sequential processes that start with the material production planning process, passes by the printable material production (supply part), then e-material production (manufacturing part) as well as the associated physical aspects of the production and the costs accumulated. Figure 4 sketches the model subsystems which are the production planning, printable material production supply, e-material production and the associated manpower and costs co-flows. Each of these processes is divided into a number of sub-processes. The printable material production is divided into three sequential sub-processes; writing, technical revision and language revision. The e-material production is also divided into two sequential sub-processes, developing and testing. In the model, we used co-flow structures to capture the amount of man-hour needed and the costs associated with each sub-process. In the following sections we will discuss each sub-model and its sub-processes.

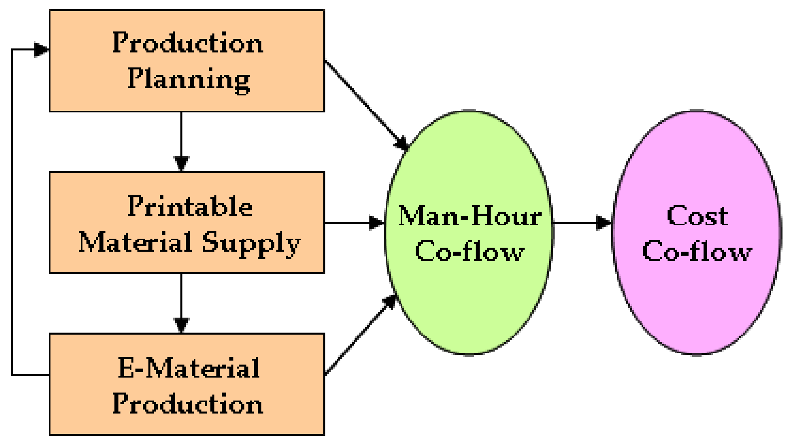

Fig 4, the ITI E-Material Supply Chain Model - Subsystems Overview

The various model subsystems will be discussed in the following sections but due to the limited space of this paper and as the structure is quite big -- as the model includes more than 260 variables -- we will only illustrate the main features of the model. The stock and flow diagram of the model is portrayed in Appendix A.

4.2. The Production planning process:

Printable production depends on the 'printable' labor available and their productivity. E-material production also depends on e-material labor available and their productivity, and is constrained to the availability of printable material supply. The demand for e-material – which is set by the ITI management – is the driving force for the production planning process. Note that demand, in this context, refers to the demand for new courses or new versions of existing courses. Figure 5 portrays the causal loop for this process.

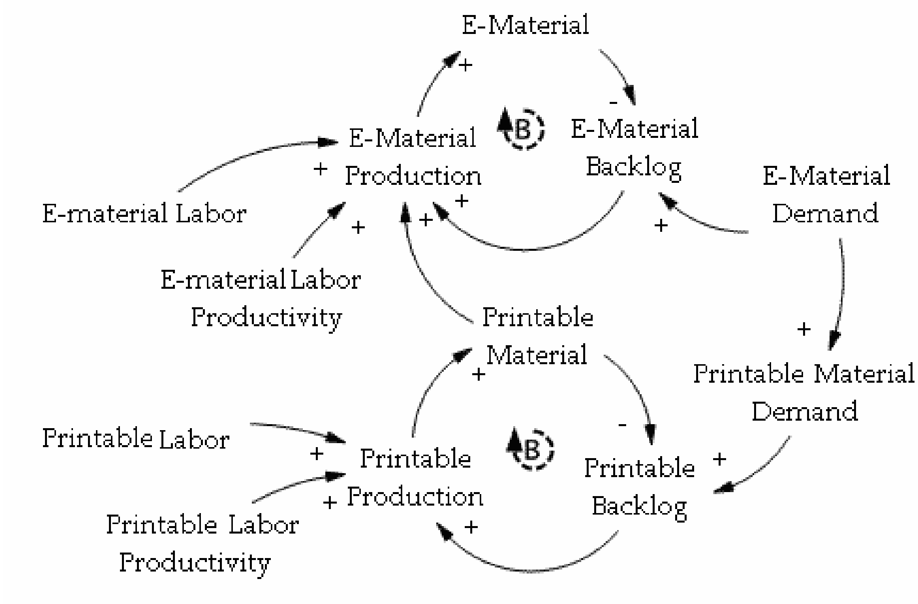

Figure 5, Causal loop for the production planning process.

4.3. Printable material production process (supply Part)

The printable material production process consists of three consequential sub-processes, writing, technical revision and language revision and the associated man-hour and costs co-flows as shown in figure 6. Printable material production starts by the writing process. The written material then are transferred to a technical revision process where written courses are either approved and transferred to a language revision process or returned again to the writing process for error corrections. After linguistically revising the courses, they are either returned for technical revision – if errors are discovered – or else approved as a printable material which could then be sent to e-material production process. Associated man-hour and costs that accumulates through each point in theses sub-process are also modeled.

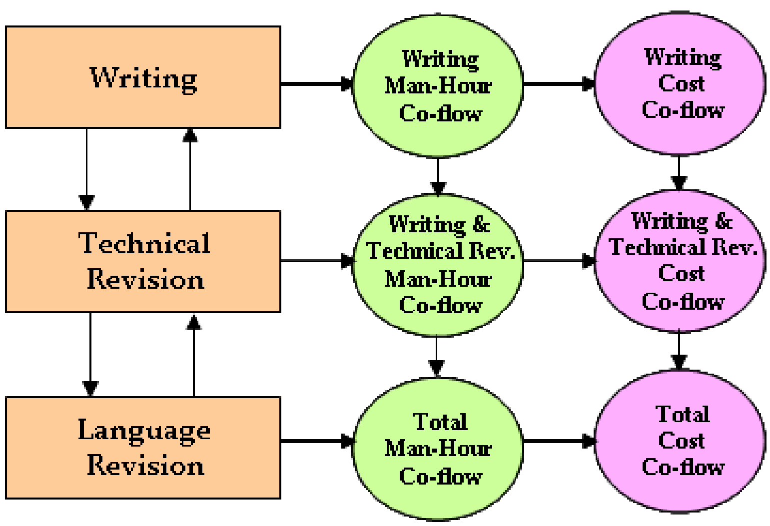

Figure 6, Printable Material Production Processes

4.4. E-Material Production Process (Production Part)

E-Material production process consists of two consecutive processes; development and testing as shown in figure 7. E-Material production is limited to material supplied availability, available labor and the available work week hours. Production is initiated by a desire to fill the gab between the production inventory and the desired inventory.
The production process starts by the development process and ends by a testing process before it can be totally approved as an e-material. Developed courses that are transferred to testing process are either approved as an e-material or returned back to development process for error correction. Again associated man-hour and costs that accumulates through each point in theses sub-process are also modeled.

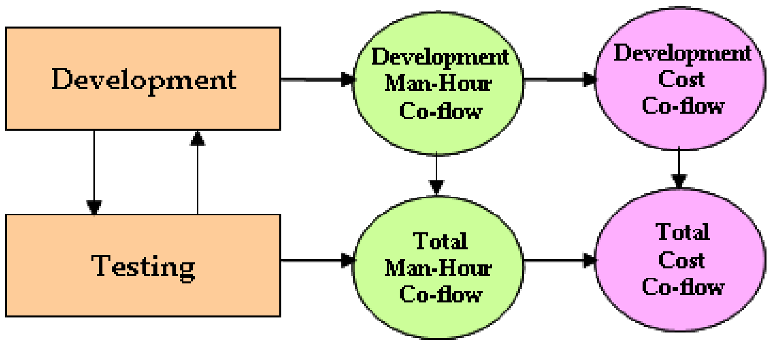

Figure 7, E-Material Production Sub-Processes

4.5. Sub-process causal loops

Each of the three sub-processes of printable material production and the two sub-processes of e-material production is a stock management structure that includes a supply line of uncompleted courses. Production supply is the buildup overtime of the production rate, which is limited by the production capacity. Production backlog is the gab between the desired and actual production inventory. The causal (feedback) loops responsible for any of these production sub-processes will be explained below by taking the writing process as an example. For example, figure 8 shows the causal loops that dominate the writing production process. Writing is initiated to fill the gap between 'desired written courses' and the actually written courses. But production is limited to the 'writing' labor, their productivity, and the available time for writing (measured in hours per week), which is a function of writing schedule pressure.

The written courses are transferred to the technical revision sub-process for review. Writing errors which are discovered by technical revision are returned to the writing sub-process (courses' authors) to be corrected.

In Figure 8, the red loops explain the mechanism that causes writing errors and the corrections taken if these errors exceed acceptable error levels. The writing labor skills and the schedule pressure affect the writing performance (which is measured by the number of errors produced). Technical revisers then compare the writing errors to the acceptable error levels; if they exceed the acceptable, the courses are returned to the authors for error correction. Acceptable error levels are set by ITI to measure the quality of the written course; it is usually set upon asking students' on their feedback of the acceptable level of errors in the course.

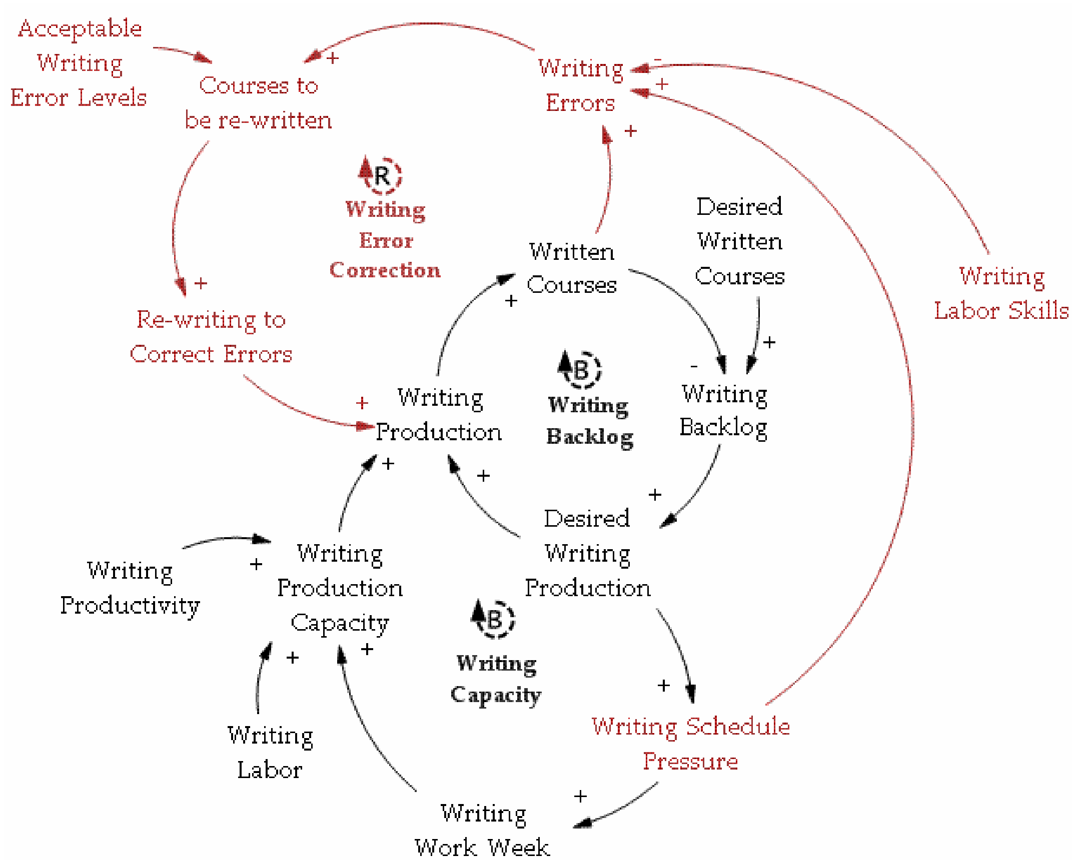

Figure 8, Causal loop for writing production and correction

5. Model behavior

5.1. Validation and diagnosis

After structurally validating the model, we behaviorally validated it by setting the 'simulation start time' to January 1st 2003 (which was the real start time for this supply chain); and running the model till January 1st 2005; then comparing the simulated behavior to the real behavior of some key variables. In this section, we present this behavior validation process, and the analysis of the behavior in order diagnose the system – i.e. identify the major problem in the system. Such a diagnosis is important in order to prescribe the proper treatment (i.e. policies), as illustrated in section 6. In section 5.1, we will focus on the printable material sub-model, while in section 5.2 we will focus on the e-material sub-model.

5.2. Printable material production

Figures 9 and 10 compare the behavior of the simulated printable material stock, and the associated simulated cost, to the real ITI printable stock, and the associated real cost. Looking at these figures, reveal that the outputs of the model have the same pattern as the real data.

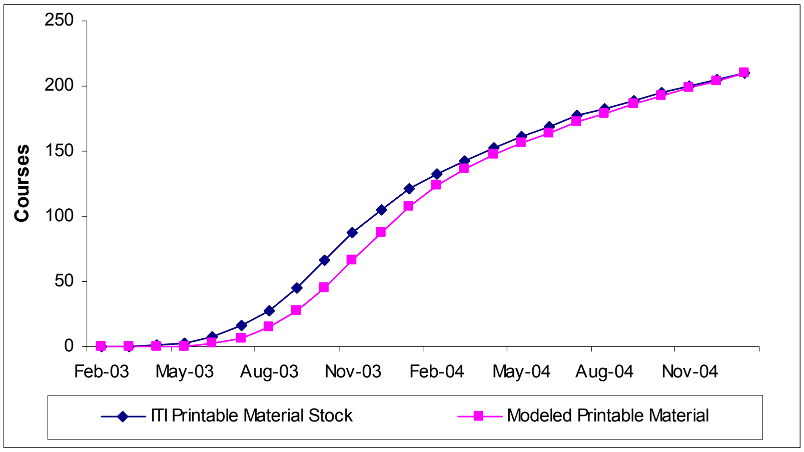

Figure 9, Real printable material courses compared to simulated courses

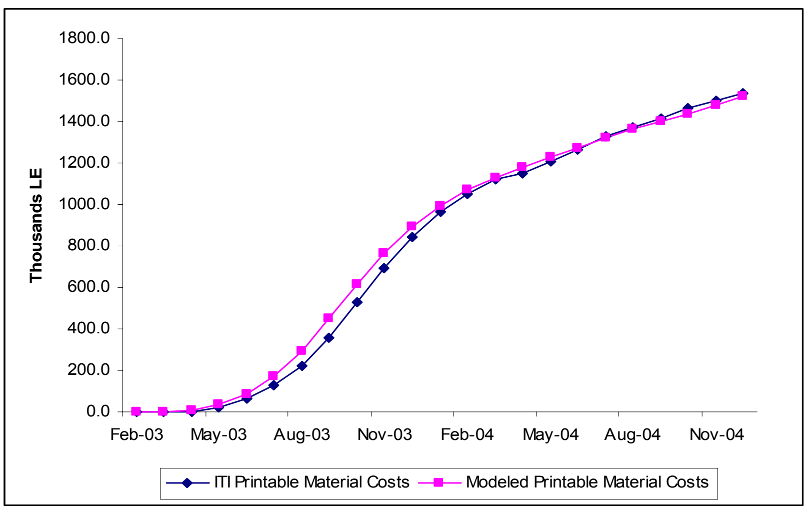

Figure 10, Real accumulated printable material costs compared to simulated costs

Below we are going to analyze the above figure using the various simulation results. The key issue – as portrayed in figure 11 – is that the accumulated amount of work spent to produce (accepted) printable material (which serves as the foundation for the various e-courses) is much greater than the accumulated amount of work spent to produce the written material . The difference is the amount of work done to overcome the writing errors. The hours spent to overcome writing errors are more than triple the amount of work to write the material. By the end of simulation, average man-hours spent on writing a course are around 225 hours, while average man-hours to reach a technically and linguistically revised and accepted course is around 690. In short, 'writing errors' is a major problem in the system; for this reason, in the policy analysis section we will devise new policies to overcome this major problem.

Note that each sub-process has a different production time and a different error level. Writing a course takes 12 weeks and the returned material from technical revision is around 50%. Meanwhile, a course technical revision is done in 4 weeks and the returned material from language revision is around 37%. While language revision takes only 2 weeks for the course and is the last process in the printable material production processes.

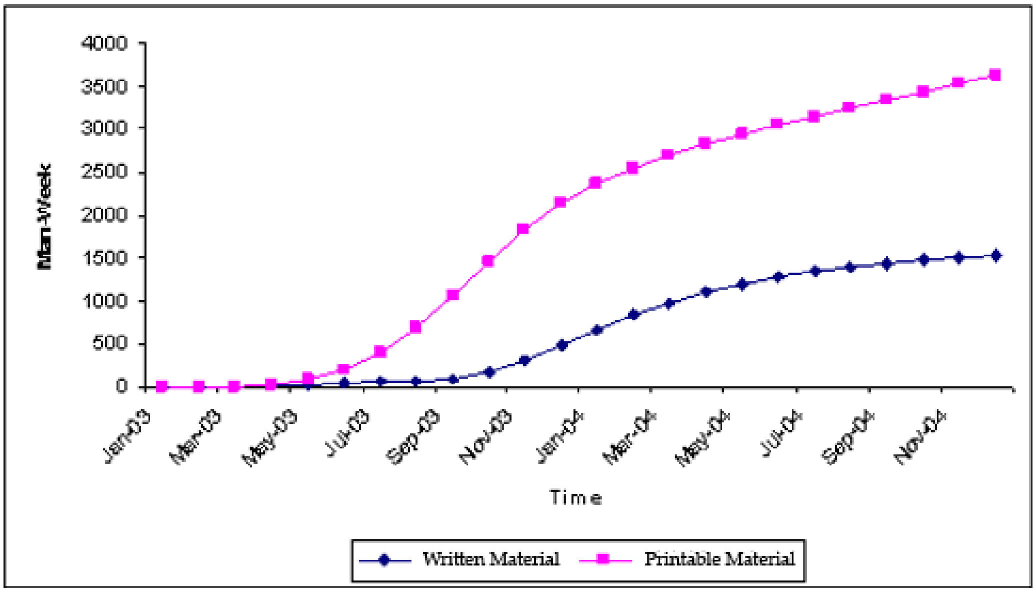

Figure 11, Accumulated amount of work for printable (acceptable) material vs. that of written material

Costs are calculated as a function of the man-hour spent to perform the various tasks, and include salaries of labor and the costs of resources required for these labors to perform the tasks. Consequently, costs accumulate in similar behavior to man-hour accumulation.

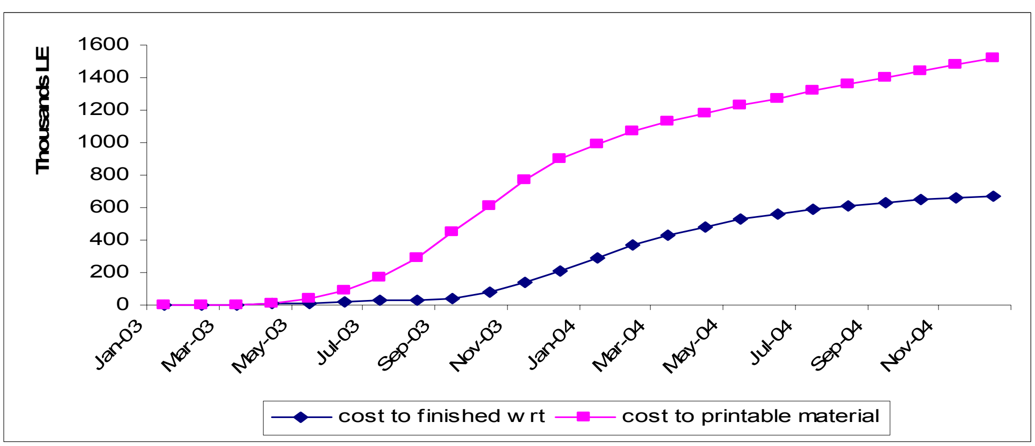

Figure 12, Accumulated Costs of Printable material vs. that of written material

Figure 12 shows the difference between the costs to write courses and the costs to improve the written course quality by correcting technical and linguistic errors. Average money spent on writing a course is around 2475 LE, while average money to reach a technically and linguistically revised and accepted course is 7234 LE (more than triple the amount needed to write the course).

5.2. E-Material production

Figure 13 compares the real stock of e-material courses to its corresponding simulated stock in the model; by the end of the 2 years simulation the e-courses reached 94 e-courses, while the actual number of courses is 90 e-courses. The simulated accumulated cost of producing those e-courses reached around 2 millions LE which is the same as the real costs.

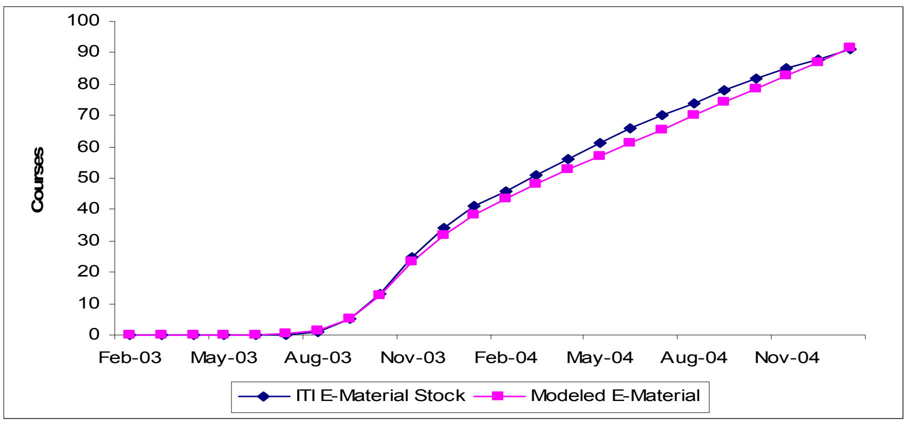

Figure 13, Real e-material courses compared to simulated courses

Figure 14 shows the behavior of the cost accumulation due to development only and that accumulated due to all processes done to produce an accepted e-material. The difference between the two curves is the amount of money needed to detect and correct development errors -- i.e. testing and debugging. So 'development errors' is also a major problem in the system. Note that these e-material costs do not include the costs of the produced printable material; but only the costs of additional work done to transform the printable material to the digital form.

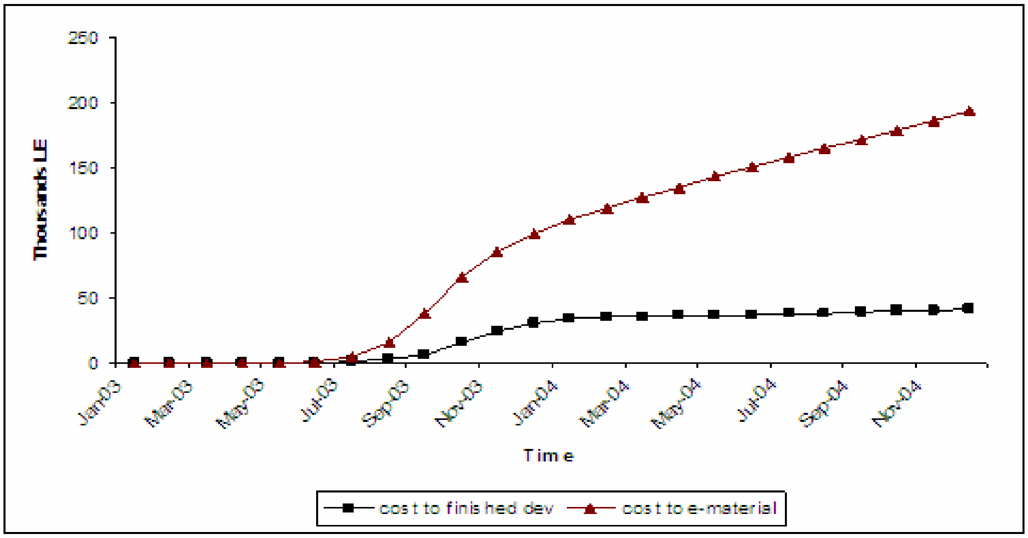

Figure 14, Accumulated Costs of producing accepted e-material vs. that of development only.

6. Policy analysis

6.1. Overview

The aim of the model is to understand the structure of the e-material supply chain; this set the stage to test and evaluate different policies that would reduce costs, while taking into consideration the production supply line stability (reduce production inventories oscillations). Actually the ITI thought of different policies to improve the e-material supply chain. But testing a policy before applying it was not possible without the help of a model to assess such policy. Using the model we can evaluate the suggested policies, and thus choose what best suits the ITI e-material supply chain. The ITI management had some initial thoughts about two policies that could reduce cost and enhance the quality of the courses (i.e. reduce the errors). One policy is to relate the salary to the number of errors produced. The other is to train instructors to improve their production skills. Each policy is introduced to the model, at the start of 2005, and then at the end of 2006, the results are compared to the corresponding results in the base run.

The following discussion shows how each policy affects model behavior. At the end of this section, we will summarize the results of each policy, in order to compare the different policies.

6.2. Salary Policy

This policy suggests that the salary becomes a function of the errors produced; i.e. to deduct an amount from the salary proportional to the errors produced by an instructor. This policy was introduced, to the model, at the start of year 2005, and its effect was evaluated after years (i.e. at the end of 2006). Figure 15 compares the behavior of the accumulated costs of e-material in the base run with the corresponding behavior in the salary policy.

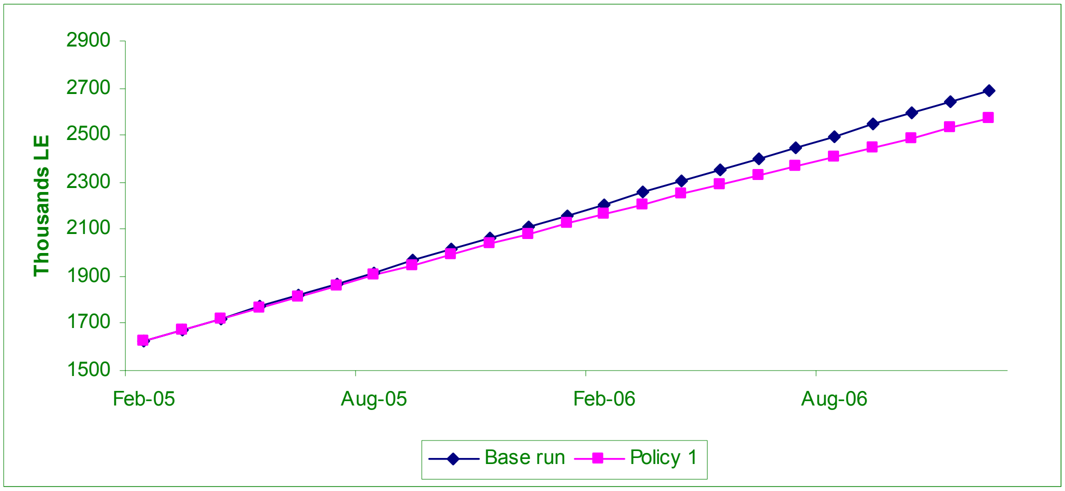

Figure 15, Accumulated Costs of e-material – base run vs. salary policy

This policy succeeded in slightly reducing costs. Note that despite that the average cost of course writing was reduced by 32 % (due to salary deductions), the accumulated costs of the printable material was only reduced by 5 %; this is mainly because we still have a large number of errors in the written courses even after introducing this policy. In a similar fashion, the average cost of course development was reduced by 12%, however the accumulated e-material costs was only reduced by 2%. So, as a conclusion, this policy alone was not able to solve the major problems of 'writing errors' and 'development errors'. In other words, you cannot solve problems by punishment alone. You must tackle the root causes of the problem – i.e. you must understand why the ITI instructors make errors. This is mainly because errors results from the inadequate skills of ITI instructors in e-material authoring. They may be excellent instructors in direct teaching, but their skills in e-material authoring needs improvement. In the next session we will discuss a training policy, to increase ITI e-material authoring skills.

6.3. Training Policy

This policy is also introduced at the beginning of year 2005. The suggested training should be effective enough to increase performance (i.e. reduce errors) and reduce production time. The ITI is currently studying training offers in this context. The training companies claim that their training would affect the average individual performance with a certain level. It is estimated that, on the average, training the instructors who perform writing reduces writing error with more than 20% and reduces writing time by 15%, technical revisers training reduces technical revision errors by 5% and the reduces technical revision time by 5%, while training developers also reduces development errors by 5% and reduces the development time by 5%. Yet the overall performance of the system has to be evaluated after assuming these enhancements in the individuals' performance; thus in the model we changed average errors and production times to reflect the improvements offered by training, and then made a simulation run. The table below summarizes the effect of applying this policy:

Variables	Policy Effect
Average Man-hour for printable material	**19% Reduction**
Total Man-Hour For Printable Material (Man-Hour)	**19% Reduction**
Total Costs For Printable Material (LE)	**19% Reduction**
Average man-hour for e-material	**7% Reduction**
Total Man-Hour For e-Material Production **(Man-Hour)**	**7% Reduction**
Total Costs For e-Material Production (LE)	**6% Reduction**

Table 2: Effect of Training Policy on Key Variables

6.4. Combining the two policies

Applying the salary policy will affect the instructors' salaries; this will eventually motivate the instructors to improve their skills in an attempt to increase their income. So the instructors will seize any training opportunity that can enhance their skills. So, in the model, we combined the two policies to see the effect on the overall performance of the ITI e-material supply chain. As indicated by the table below, combining both policies would lead to better results. The beauty of these simulation experiments is that they produce quantifiable results for the expected improvements of introducing each policy.

	Salary Policy	*Training Policy*	*Policies combined*
Average Man-hour for printable material	**No Effect**	**19% Reduction**	**19% Reduction**
Total Costs For Printable Material (LE)	**5% Reduction**	**19% Reduction**	**21% Reduction**
Average man-hour for e-material	**No Effect**	**7% Reduction**	**7% Reduction**
Total Costs For e-Material Production (LE)	**2% Reduction**	**6% Reduction**	**7% Reduction**

Table 3: Policy Benchmarking

7. Conclusion

This study aimed at understanding the dynamics and complexity of the ITI e-material supply chain. Through the study a system dynamic model was build to reveal the underling structure of this supply chain and to evaluate different policies which could help increase its overall performance. The model provides a very good tool for answering the research questions. The model succeeded in understanding the nature of the e-material supply chain at the ITI, and revealed that the long production times and costs are mainly due to the rework associated with correcting production errors. While it seems that ITI succeeded on the short run in raising the quality of its e-content by adding several revision and quality assurance procedures, but on the long run this will lead to increased costs and heavy production schedules to correct the errors discovered by the revisers. A long term actions must be considered. Several policies were suggested to enhance performance and reduce costs. These polices included relating labor salaries to the production performance, training labor to increase performance and reduce long production times, and the combination of both policies. Each policy was discussed and evaluated. Salary policy has a significant effect on cost, while the training policy has a significant effect on reducing production time -- by reducing rework -- and consequently costs. Combining the two policies leads to combining the successful results of both policies, and thus we suggest applying both policies at the same time to improve ITI e-material supply chain performance.

Future work could enhance the model structure by adding a sub-model for capacity formation (i.e. hiring new staff), or could extend the model boundary to include the e-students behavior and e-learning market, or could extend policy analysis to suggest and evaluate other policies. Moreover, the simulation model built could be adapted to any similar e-content supply chain with an authoring production process and quality assurance processes.

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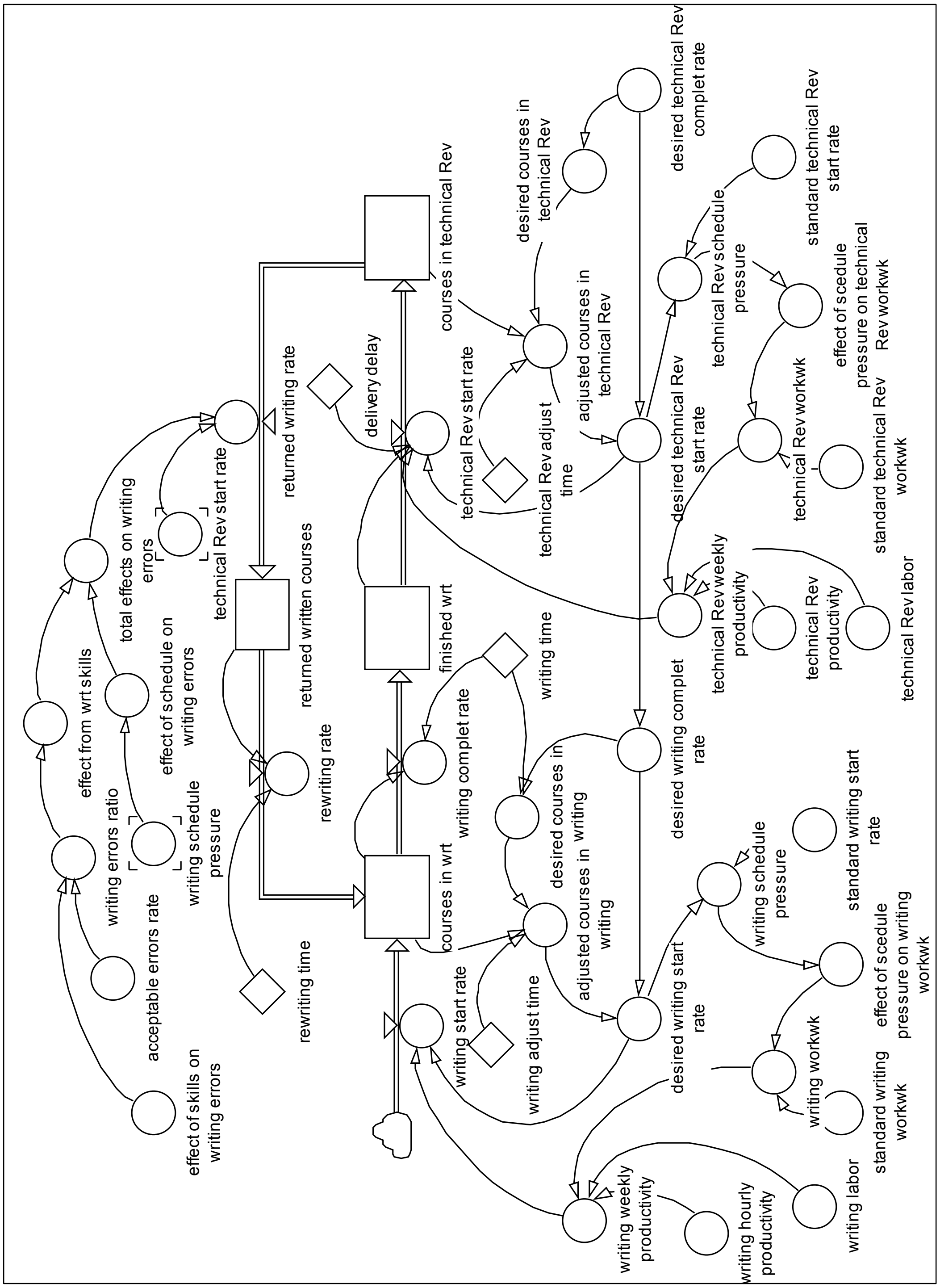
Internet Sites:

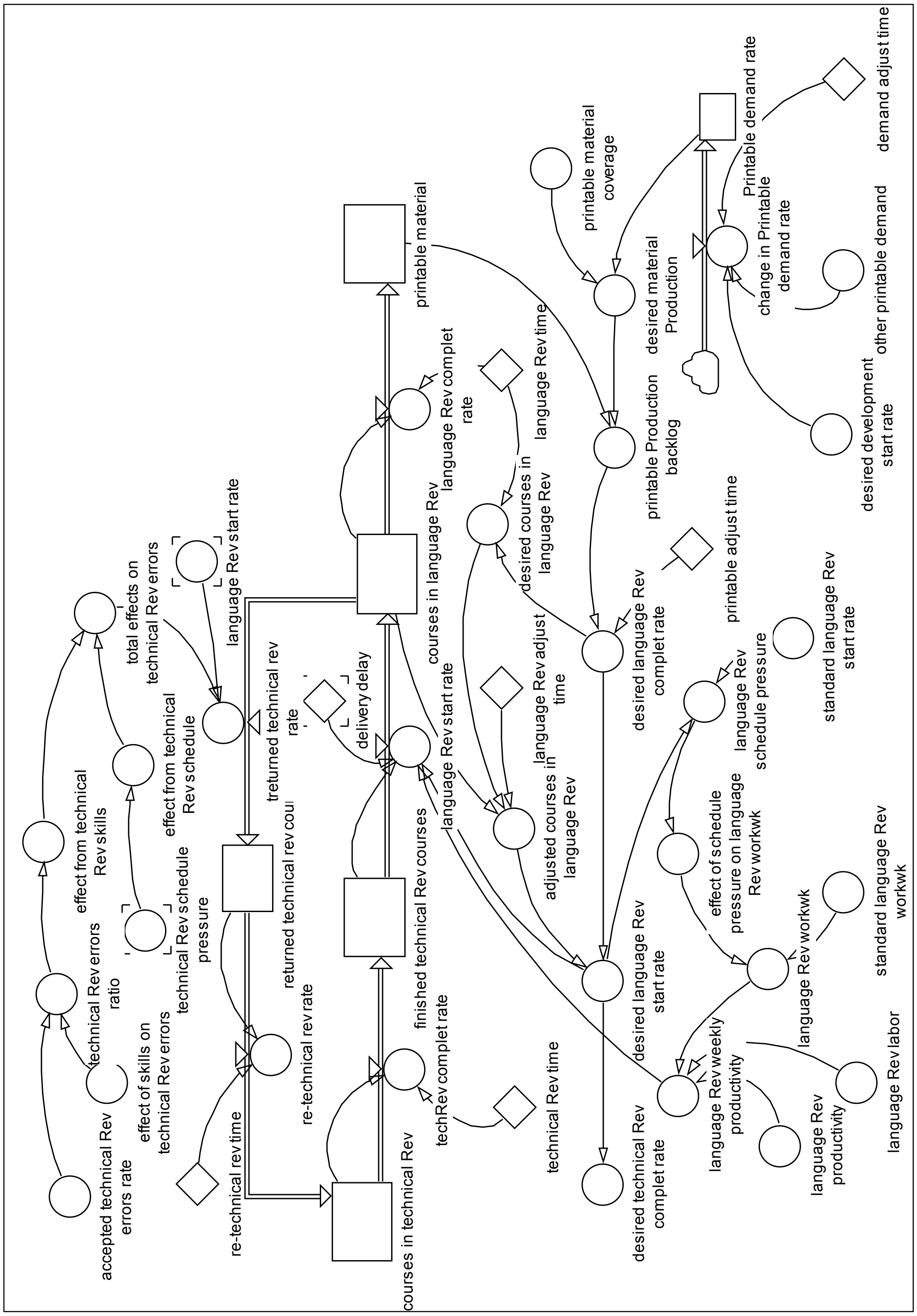
- The Information Technology Institute (ITI) website: http://www.iti.gov.eg
- The Virtual ITI (VITI) Portal: http://www.viti.gov.eg
- Ministry of Communication and Information Technology (MCIT): http://www.mcit.gov.eg

Appendix A: Stock and Flow Diagram

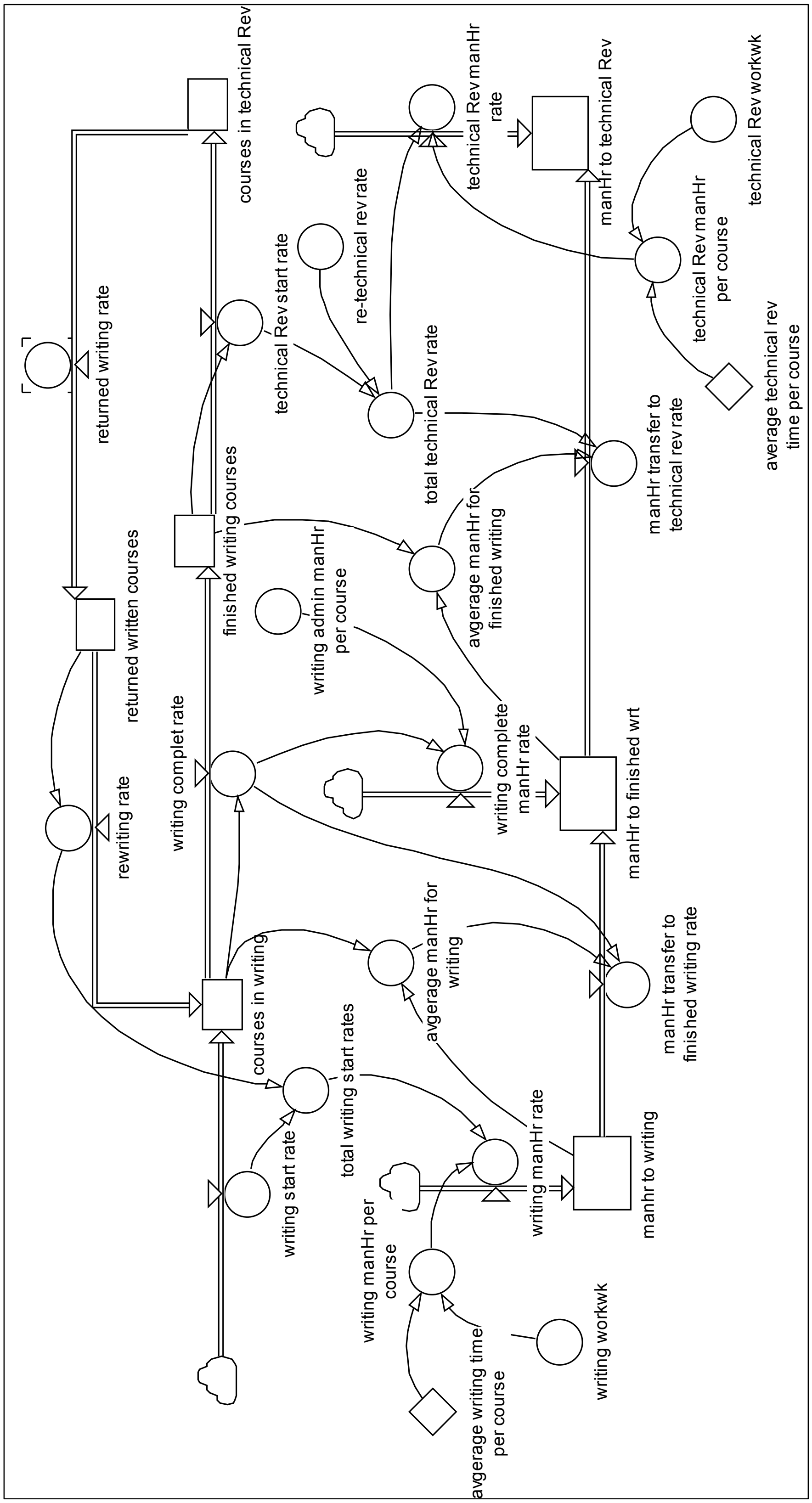
Writing / Technical Revision Production Sub-processes



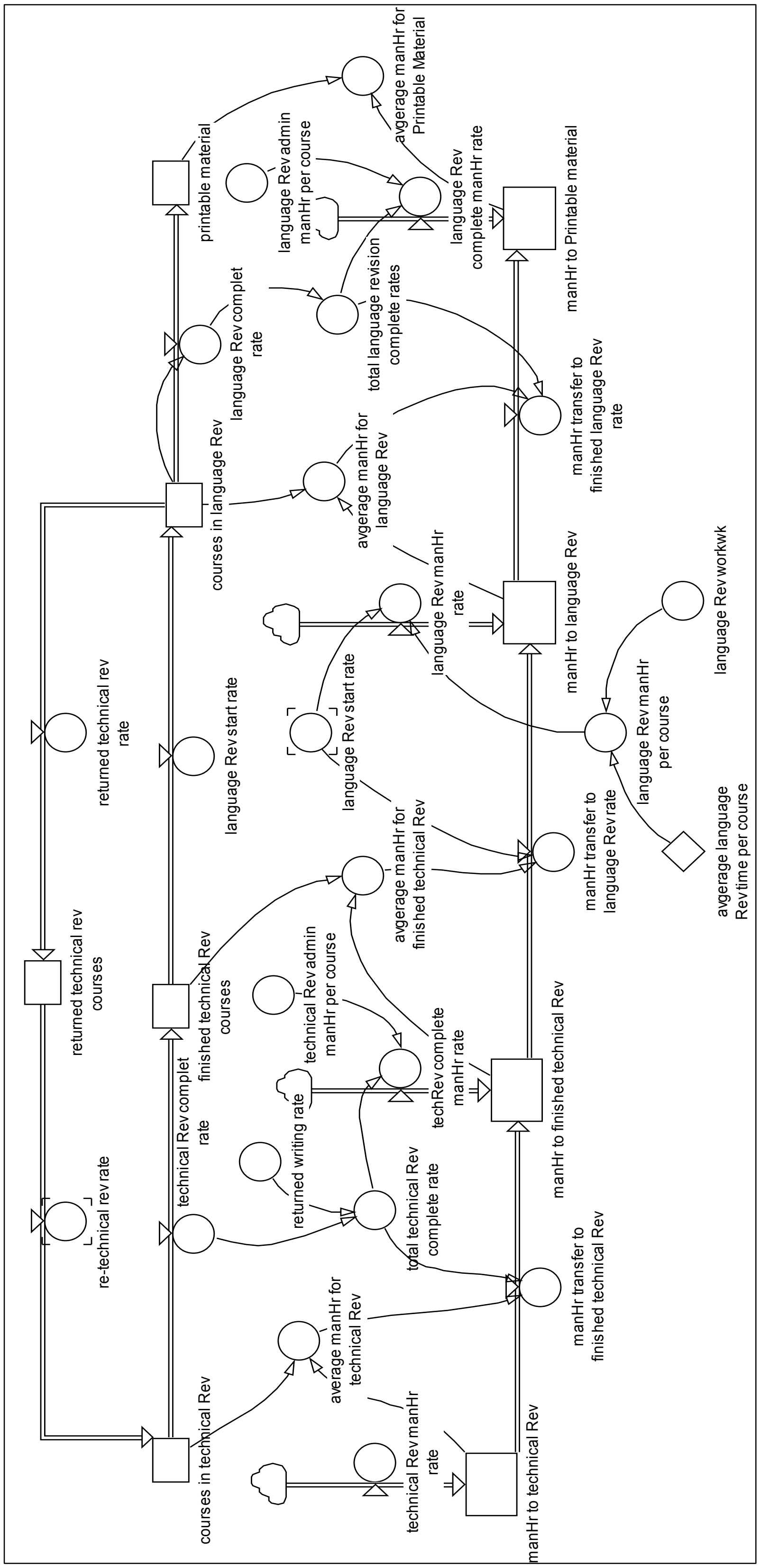
Technical Revision / Language Revision Production Sub-Processes



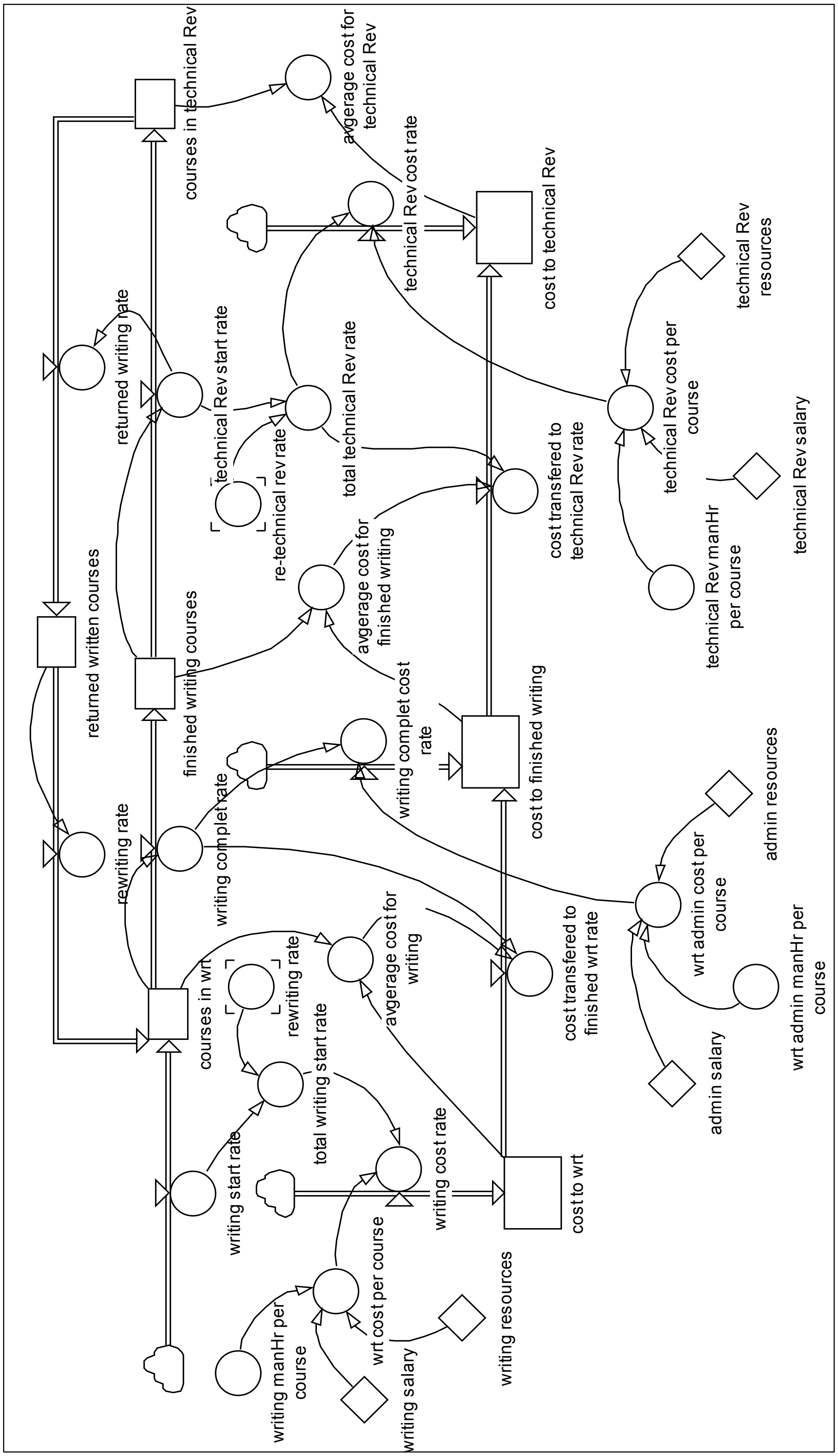
Writing / Technical Revision Man-power Co-Flow



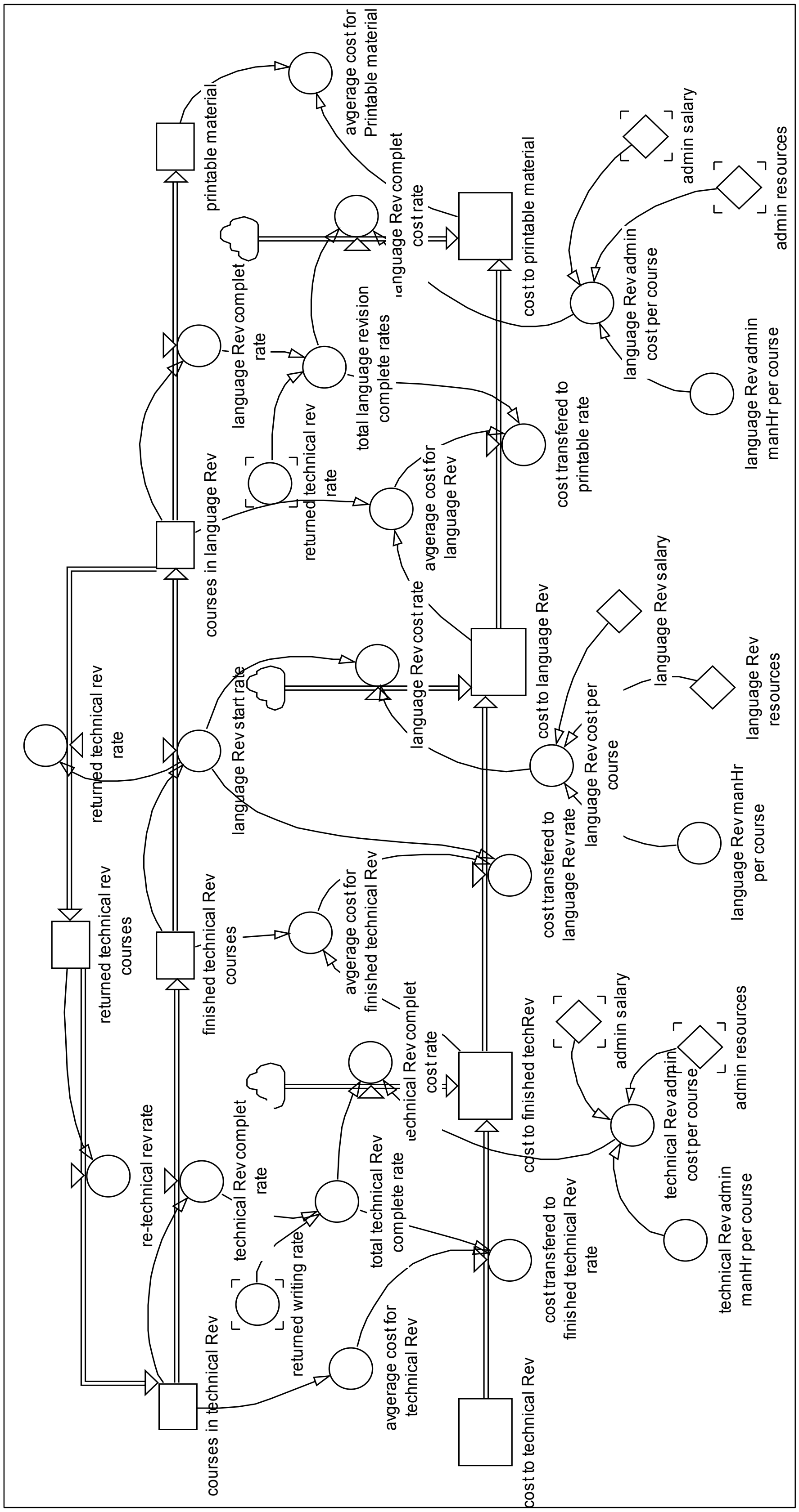
Technical Revision/ Language Revision Cost Co-Flow



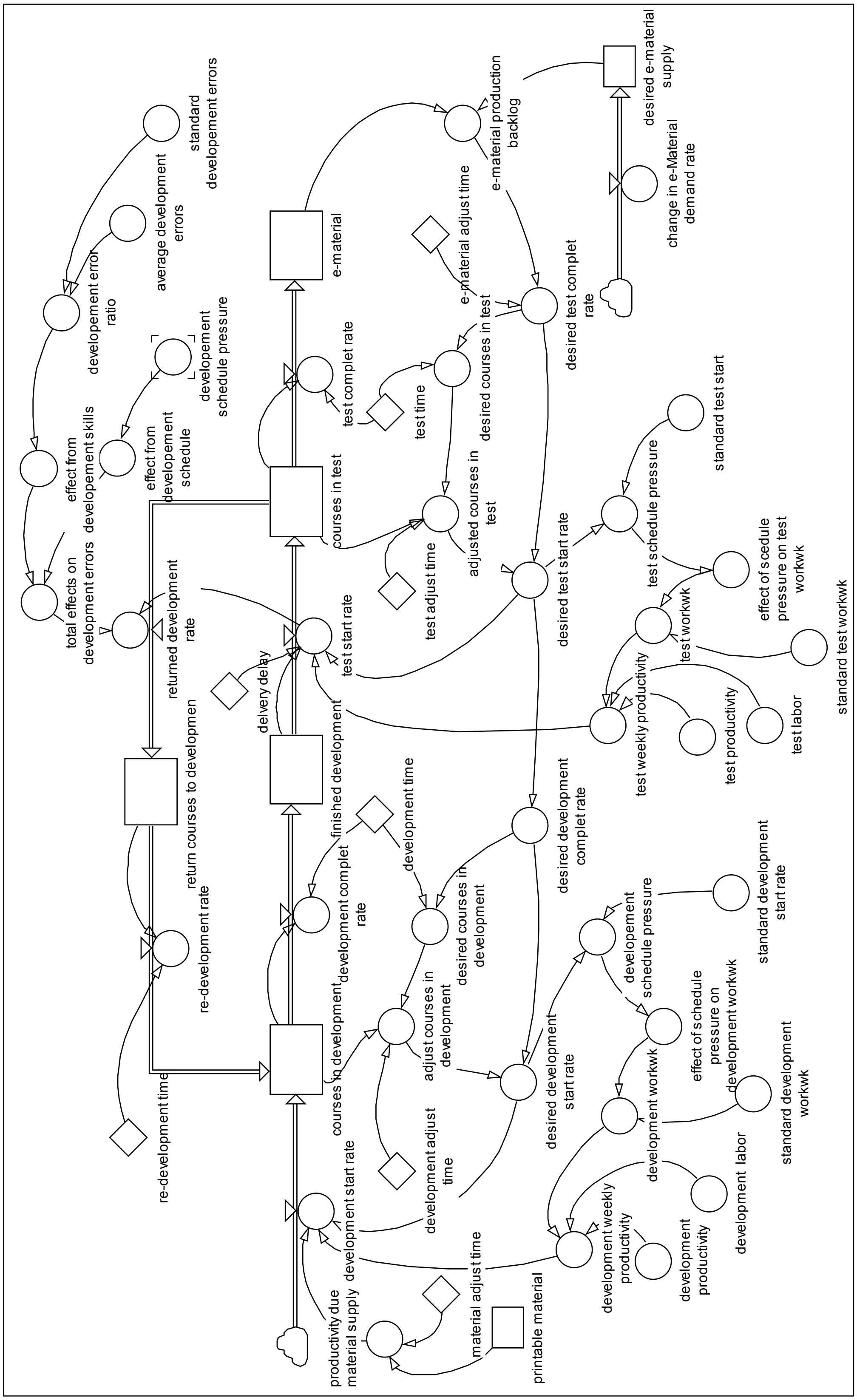
Writing / Technical Revision Cost Co-Flow



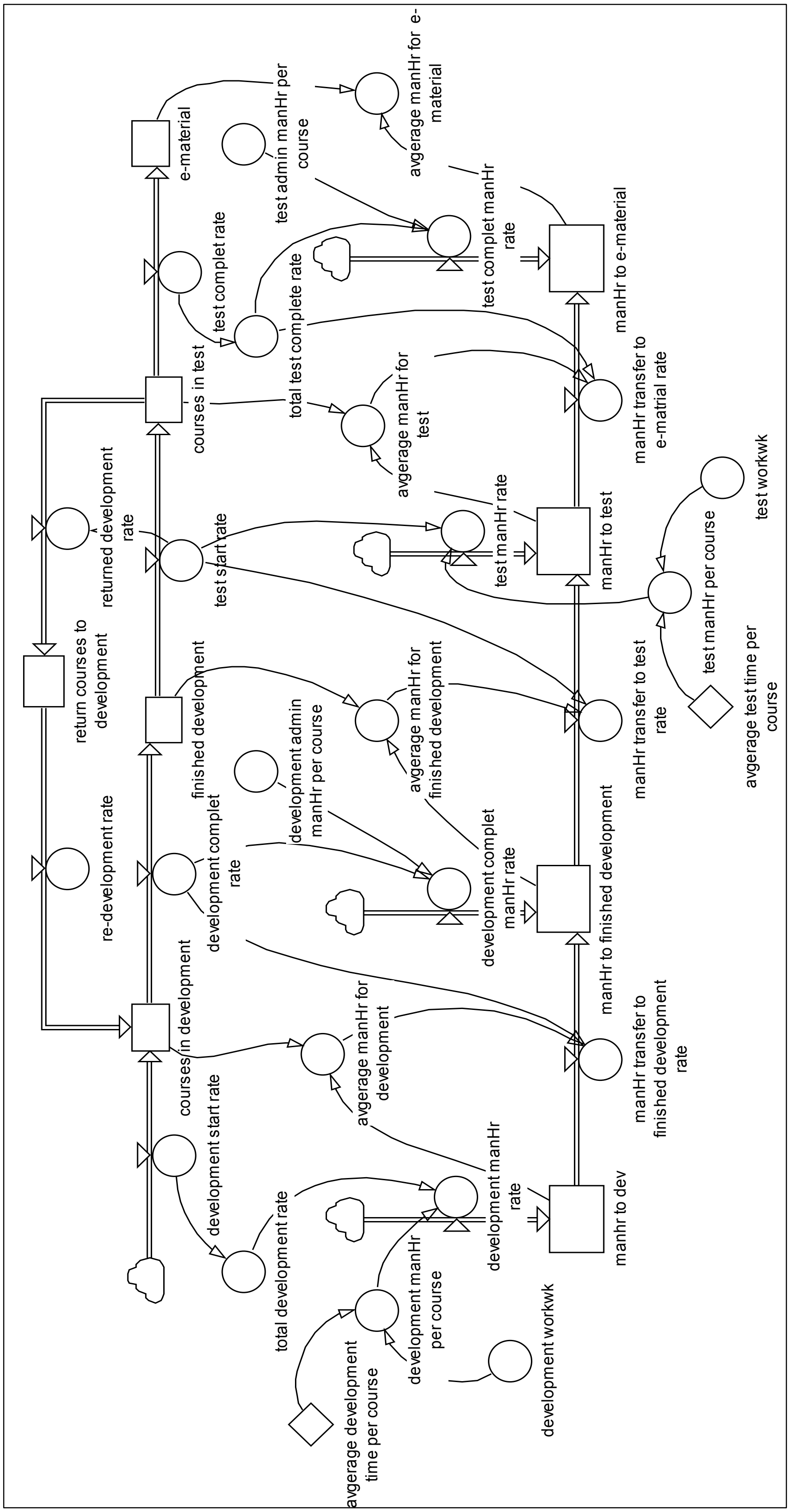
Technical Revision/ Language Revision Cost Co-Flow



E-Material Production Sub-Processes



E-Material Man-power Co-Flow



E-Material Cost Co-Flow