A system dynamics model of the efficiency of primary education in Latin America.

Ben Terlou
Etzel van Kuijk
Jac A.M. Vennix

Hogeschool Midden Nederland
P.O. box 131
4100 AC Culemborg
The Netherlands

Abstract
In this paper the problem of low efficiency of primary education in Latin America is described in a Stella model. With this model several policy experiments are conducted, the results of which emphasize the need for a careful consideration of the alternative policy options. Problems of the translation of the conceptualization into the Stella model are resolved only in part. Further lines of development of the model are suggested.

I. Introduction
Much has been written about the problem of low efficiency of primary education in Latin America.Dropout and repeating rates in many countries are high, and the quality of teaching results in terms of functional literacy is low (Unesco, 1986). Beside factors related to the functioning of the educational system attention has been given to more general variables like the economical, political and cultural conditions of a country. In general: the developmental conditions of a country. Although these undoubtedly are important elements, in this paper we will focus primarily on factors within or closely related to the educational system. With the emphasis on the internal structure and dynamics of the system, in its relation to the dropout and repetition rates, we hope to clarify some of the (feedback) processes causing low efficiency. We will focus on two main aspects of the educational efficiency problem. First the generally high rate of dropout, and secondly, the equally high rates of repetition. In the literature on the subject we find that, despite small differences, mostly in emphasis on certain types of factors determining low efficiency, there is generally a high degree of consensus on the most important factors (de Moura Castro, 1984;Dubbeldam, 1988). Most of the factors, however, are discussed in relative isolation from one another. The obvious disadvantage of such an approach is twofold. First, it does not reveal interactions between these factors in determining low efficiency. Second, the effects of policy measures aimed at increasing efficiency rates are hard to assess. In order to shed more light on the potential effects of various educational policies we designed a system dynamics model of primary education in Latin America, and, more

specifically, in Central America.
In section 2 we will present the problem definition of our study. In the following sections we will discuss the construction of the model. These sections will focus on the identification of causal factors and feedback processes determining the level of efficiency. Subsequent sections will be concerned with the model's dynamics, i.e. the base run, sensitivity analyses and policy experiments. It is this use of the model as a simulation model, which gives it practical value for policy makers. In the last section we discuss unresolved problems in the model construction.

2. Problem definition

As stated above the low level of efficiency of the primary educational system is primarily indicated by high dropout and repetition rates. In table 1 we have reproduced some figures which form part of the reference mode of behaviour, revealing these rates.

Table 1: The percentages of the original cohort that reach the next class. The average percentage for Costa Rica, El Salvador, Guatemala and Nicaragua

	Class1	Class2	Class3	Class4
aver perc.	71.23%	60.95%	53.13%	46.48%

As can be seen from this table dropout rates are consistently high despite the fact that several governments have implemented policies to improve the efficiency of the system. Policies obviously have not been very effective, possibly, apart from evident economic problems, because of a number of unidentified feedback processes counteracting government policies. The model building process was guided by the following questions:

1. What factors and feedback processes might be held responsible for the low level of efficiency of the educational system in Latin America?
2. What policies might yield effective improvement of the performance of the educational system in Latin American countries?

Of course the situation in the different Latin (Central) American countries cannot be compared in a straightforward manner. Although problems of developmental and economic nature prevail in the whole of the region, in some countries problems of political and/or cultural character predominate (e.g. Guatemala and Nicaragua). Countries with a largely indigenous population like Guatemala are confronted with cultural and linguistic problems. An analysis of the problem of low efficiency of primary education evidently has implications which reach farther than educational policy. In this article we focus however on the educational aspect of the problems.
In the process of construction we have encountered many problems, technical as well as in content, only part of which we have resolved satisfactorily. Hence, we have been in a position to translate only part of the conceptual model into a Stella model. Several concepts have not been included in the model, due to prob-

lems of units of measurement, impeding the establishment of exact relationships between variables. In the discussion of the model these concepts will nevertheless be mentioned. In the last section of the article we will return to these problems and suggest possibilities to further improve the model. In the next section (3) we will concentrate on the problem of low promotion rates and consequent high repetition rates. We will first discuss factors related to the quality of learning (section 3.1). Next we will focus on factors affecting school attendance by children. We will make a distinction between actual hours at school (section 3.2) and the absence of pupils (section 3.3). In section 4 we will discuss factors affecting dropout.

3. Promotion (repetition) determinants: the quality of learning

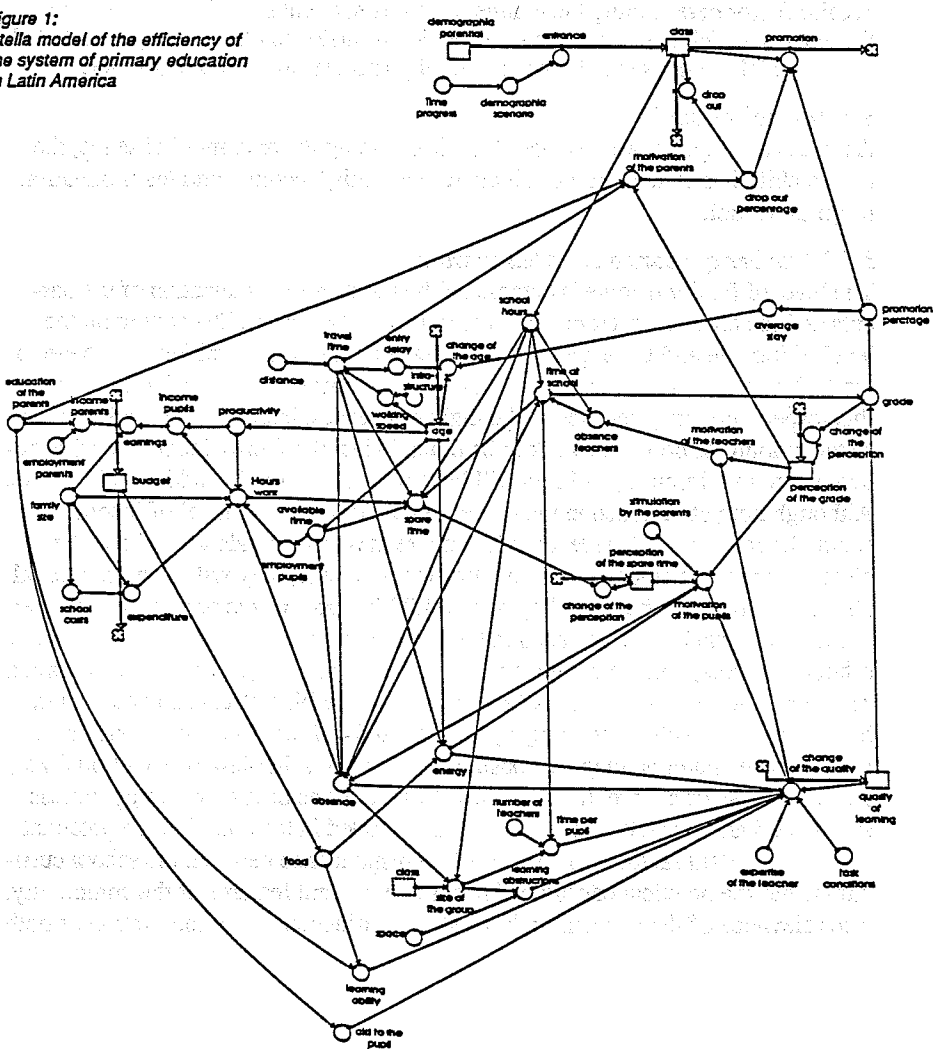
The central part of the model is the chain of levels representing the flow of pupils through the grades, entering the school, being promoted (or not) at the end of the year, or dropping out during the year. For reasons of simplicity, we will represent just one level (grade) and the structure of factors and relations determining the processes of promotion, repeating and dropout (see figure 1, next page). In the following explanation the names of the factors in the model are indicated in parentheses, if they are different from the decriptive term.Promotion rates are primarily determined by the attained grades. There are several main causal chains leading to the promotion or nonpromotion (*repeating*) of pupils. The first centres around the concept of *quality of learning*, which determines the level of achievement of the pupils (*mark*). The second relates to the amount of time the pupils spend at school (time at school). Both affect the grades attained and subsequently the promotion percentage.

3.1 Quality of learning

Quality of learning is a complex concept, affected by several factors. Not dynamically related in the model are: task conditions (available learning- and teaching materials; furniture; space) and the expertise of the teacher (Avalos, 1986). Dynamically determined variables are related to characteristics of parents, i.e. their assistance to their children in doing schoolwork (*aid to the pupil*), which in turn depends on level of their schooling (*education of the parents*). The level of education of the parents, and especially of the mother, is mentioned in several publications as an important factor determining the achievements of pupils (De Moura Castro, 1984). A central characteristic of teachers affecting the quality of education is their motivation to make an effort (*motivation of the teachers*). Size of group determines the level of learning obstacles, such as the visibility and degree to which the pupils can hear the teacher. Other variables are the amount of time the teacher has for individual instruction and monitoring learning processes (*time per pupil*) which is determined by the *size of the group* and the length of the schooldays (*school hours*), and the motivation of the pupils. This latter vari-

able will be discussed later on.In addition *learning ability* of the pupil plays an important role, and his level of mental development as determined by the degree of (early) *stimulation by the parents* (Irwin et.al.,1978). This in turn is affected by the level of *education of the parents*. In the model this relation is represented by a direct link between the level of education of the parents and the learning ability of the children.

Figure 1:
Stella model of the efficiency of the system of primary education in Latin America



3.2 School hours

The second factor affecting attained grades and thus promotion rates is the amount of time pupils spend at school (*time at school*). Amount of time spent at school depends on the timetable, the absence of pupils (*absence*) and *absence of teachers* . The timetable is determined by the capacity of the school. When there are too many pupils (a shortage of teachers), the class may be divided in two groups and taught by the same teacher in succession. Naturally this reduces the length of time at school for the pupil. In the model we determined a critical level for group size (i.e. 50), above which the group is divided in two parts, functioning as parallel classes. The absence of the pupils is a function of the necessity to work and the motivation of the pupils to go to school. These variables will be discussed in more detail in the next section.

A third factor determining the number of hours spent at school is the absence of the teacher which is related to his motivation to make an effort. Not yet included in the model are the status in the community and the salary of the teacher.

3.3 Absence of pupils

As stated above there are two variables determining the amount of absence, the time a child has to work to contribute to the family income, and his motivation to go to school.

3.3.1 Number of hours a child has to work

The level of family income is determined by the degree of education of the parents and the chances of employment (*employment parents*). Depending on the level of income and the expenses for living and school, the children will have to work. The size of the family (*family size*) is of course a first consideration in this respect, not only because of the higher expenses, but also because it increases the amount of domestic work to be done. When the family income level is below a certain minimum, children will have to work to provide additional income. Although not yet included in the model, other effects of the level of income should be mentioned. The level of income relates to the tendency to keep the child at home. When parents have a low income level, they will be more critical about the payoff of the schooling of the child in terms of the perspective of later schooled and paid work. Included in the model are the distance between home and school (*distance*) and the quality and amount of food (*food*). The distance between school and home is important because of the far reaching effects on energy and health, or on the school entering age of the pupils. If the distance is considered too far by the parents, they will postpone the actual schooling of the child (*entry delay*). In case of a large distance, the effects in terms of loss of energy, illness and demotivation can be considerable.Not included in the model, but a potentially very important factor is the degree of correspondence between the school curriculum and the practical educational needs and cultural features of the community. The relevance of the curriculum has a strong influence on the motivation of both

pupils and parents (Unesco, 1980).

3.3.2 Motivation of the pupils

A second variable influencing the degree of absence is the motivation of children to go to school (*motivation of the pupils*). This factor is the result of several other factors. As in the motivation of the teacher, the achievements of the pupils will play a role (*perception of the grade*), because of its potential reinforcing effects, especially when the parents are motivated to send their children to school (Irwin et.al. 1978).

Beside achievement external influences like the pressure on time for school and work are important. When a child has to do much work and needs much time to cover the distance between school and home (*travel time*; determined by the distance between home and school, the walking speed of the child, and the quality of the available roads- *infrastructure*), little time will be left to rest and enjoy social and playful activities (*spare time*). This will demotivate the child. The degree of stimulation the parents provide the children is also an important factor.

Included in the model is the energy and health of the child as a factor determining the motivation of the child (*energy*). When a child lacks the energy or health necessary for school the required efforts will be unpleasant and unrewarding (in a direct emotional sense).

Not yet included in the model is the energy and health of the child determining the amount of time absent from school because of illness or tiredness. Berg (1981) reports that in some Latin American countries absence due to illness and weak health can amount to a third of the school-time. In this respect the distance between school and home is important, apart from the quality and amount of food.

4. Dropout determinants

We have to make a distinction between two forms of dropout, i.e. dropout per se and keeping children at home for one additional year. In the first case a child will stop attending school. In the second case parents decide to keep the child temporarily at home when it has reached the schoolage. Parents will decide to keep their children at home when their motivation to send the children to school falls below a critical limit. The factors determining the level of motivation have already been mentioned in the preceding section.

In particular the phenomenon to keep the child at home when is has reached the school entering age must be mentioned. In rural areas repeating in the first grade is very common (Halpern, 1986). Many young children do not possess the level of mental development necessary to profit from the instruction. Moreover they are more liable to health and safety risks when they walk to school, especially in dangerous areas like mountains or jungle (Ewalts, 1986). So, many parents decide to keep their child at home till next year.

5. Baserun

In this section we will present the results of several runs with the model. Of course, given the weak empirical basis, the model outcome will have to be considered with care.

The base run represents a quite common situation for a first class of a Latin-American primary school. It describes the following situation. The annual entrance rate is 45 pupils. Travel distance for these pupils is on average 1.0 mile and the infrastructure is 50% of the ideal situation. As a result of this travel distance and the infrastructural restrictions, the parents of the pupils will take the decision to delay the entry of their children in school. The entry delay occurs in the model as a result of that decision. This entry delay has an effect on the average age of the pupils in the class (the normal entry age is 6 years).

We estimated the level of education of the parents at 70%, which means that 70% of the parents has completed primary school. This affects the assistance to the pupils and the learning ability of the pupils, which in turn affects the quality of learning. The quality of learning is also affected by the stimulation of the pupils by the parents, which is 75%, meaning that on average three days out of four the parents will tell their children to attend school. The expertise of the teacher is estimated at 75%, meaning his (or her) skills are three quarter of the full potential, and the task conditions at only 50% of the desired level (these factors are also related to the quality of learning).

Altogether this accomplishes the level of the quality of learning, which is one of the components of the grades achieved by the pupil. The other component of the grade is the time at school. The time at school is basically 6 hours but it can decrease to 3 hours, depending on the pupil/teacher ratio, and is furthermore influenced by the absence of the pupils. This accomplishes an average grade (achievement), which determines the promotion percentage and the average time to complete the first class (the average stay). We simulated this for the first four classes. As an indication for the efficiency of the simulated school we use two figures. In the first place the percentage of the original cohort that finishes school. In the second place the average time that it takes to finish school. In table 2 we have reproduced the results of the base run of our model for the first indicator (the percentage of the original cohort). We validated the model on the average percentage per class in the region.

Table 2: Retention percentages of baserun and region

	Class1	**Class2**	**Class3**	**Class4**
baserun	71.02%	61.00%	53.13%	46.47%
aver.perc.	71.23%	60.95%	53.13%	46.48%

This close correspondence between the actual retention rates and the figures generated by the model seems surprising, but considering the fact that the factors determining these percentages are directly backed by empirical data, it is however not as surprising as may be thought at first sight. The second indicator, the average time that is needed to complete the school (in this case four grades), can be

obtained by summing the reciprocals of the real promotion percentages. Our base run evolves to the following average stay per class :

Table 3: Average stay per class in years
Class 1: 1.41 **Class 2:** 1.37 **Class 3:** 1.36 **Class 4:**1.34

This adds up to a total of 5.48 year to complete the sequence of four classes. As to the validation of the model, it will be clear that we have validated the model in a very restricted way. Other ways are suggested in the section 'unresolved problems'. However, given the above results our preliminary conclusion is that the model can be used to assess the effects of policy experiments.

6. Policy experiments

Building extra schools
Building extra schools means that not only the number of schools changes, but the number of teachers, the actual space, the task conditions and the distance as well. We chose to simulate what happens when 10% extra schools are built and equipped. Therefore we changed the entrance in class 1 (from 45 to 41 pupils: the result of 10% additional schools & teachers), increased the space and the task conditions, and reduced the distance (all the changes are estimations of the effects that building and equiping 10% additional schools will have on the mentioned variables).

Table 4: Retention percentages for different numbers of schools

	Class1	Class2	Class3	Class4
baserun	71.02%	61.00%	53.13%	46.47%
+10%	72.05%	62.02%	54.17%	47.46%

One of the effects of the rise in the grade is a higherpromotion percentage, which reduces the average stay. This can be seen in table 7.

Table 5: Average stay in years for different numbers of schools

	Class1	Class2	Class3	Class4
baserun	1.41	1.37	1.36	1.34
+10%	1.40	1.37	1.34	1.33

As can be seen the effect of this policy measure is not very impressive, especially not when we compare it to our first policy experiment, aimed at decreasing the distance to school and improving the infrastructure.

Increase the level of education of the parents
As another policy experiment we chose to simulate a situation in which the educational level of the parents is higher than the education level in the base run. An increase of the educational level of the parents could be realised by way of alfabetization programs.

Table 6: Retention percentages for different educational levels of the parents

	Class1	Class2	Class3	Class4
baserun	71.02%	61.00%	53.13%	46.47%
+1 year	73.78%	64.33%	56.78%	50.24%
+2 years	77.36%	68.64%	61.56%	55.36%

As expected, an increase of the education level of the parents affects the output of the model considerably. The surviving cohort rises from the original 46.47%, to 50.24% and 55.36%.
The explanation for the massive growth in the surviving cohort is the increase of the motivation of the parents. Next to the direct influence of the higher education of the parents, the increased perception of the grade has also a positive effect on the motivation of the parents. For these two reasons the drop out declines and the actual surviving cohort grows. The other effect of the higher grade is the decline of the average stay caused by the higher promotion percentage. This is neatly demonstrated by the table 9.

Table 7: Average stay in years per class for different educational levels

	Class1	Class2	Class3	Class4
baserun	1.41	1.37	1.36	1.34
+1 year	1.35	1.33	1.31	1.30
+2 years	1.29	1.27	1.25	1.24

The increase in efficiency of the system due to this policy measure is so great that the actual number of pupils in the class declines.
Given the results of the policy experiments, the conclusion is that, according to the model, a powerfull measure would be to rise the level of the education of the parents. Building more schools would yield a relatively small effect.

7. Unresolved problems

7.1 Validation of the model

We have tried to conceptualize the problem of internal efficiency, hypothesizing on the base of existing information the main factors and mechanisms involved in the problem. Because of this general focus we developed the model on a highly aggregated level, without being concerned with a description of specific situations. By giving the parameters average values we have tried to avoid constellations of factors with extreme low or high values representing specific situations. The results of the baserun could therefore be compared to the figures regarding the general situation of Central America. The model can be disaggregated by giving the relevant factors values corresponding with specific (national, regional) situations. Analysis of a certain region reveals specific values for instance for the distance between home and school, the professional preparation of the teacher, etc. When, on the base of such information the model is disaggregated, it can be

validated against the specific figures of dropout and repetition prevailing in that situation. This way it is possible to disaggregate the model for different types of situations, like the national situation of the different Central American countries, and validate it against the national statistics of dropout and repetition. Other variants of the model could be produced, describing for instance urban and rural types of situations, in which the factors tend to take on specific characteristic values.

7.2. Elaboration of the model

As described before, there are certain elements in the conceptualization of the problem which have not yet been included in the model. The main reason for this has been the difficulty of finding operationalizations (c.q. units of measurement) of the concepts, by which they can be related to each other.
The equations in which the structure of the hypothesized mechanisms is described, are mostly constructed on the base of experience and common sense. Especially the equation concerning the key concept of the quality of learning has been difficult. The relative part of the determining factors had to be estimated, without the aid from research evidence. Other equations are also constructed on a very narrow empirical base. To enable a productive debate on this matter, a description of the choices and arguments we made is of course a first condition.

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