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A System Dynamics model of primary and secondary education in Nicaragua

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Abstract

A System Dynamics model of primary and secondary education in Nicaragua has been developed to assist the National Ministry of Education in analysing the system of schooling and investigating the impacts of different possible policy decisions. The model shows that without a change in policy there will only be a small increase in the percentage of primary and high school coverage and that the number of illiterate people will more than double over a period of twenty years. The consequences of various policies have been investigated using the model. These policies include implementing literacy programs and introducing a program in which families in extreme poverty receive a subsidy. Preliminary results show that by combining these two policies, an effect on school coverage as well as on the number of illiterate people can be achieved.

Keywords

national educational system, System Dynamics model, primary education, secondary education, Nicaragua

Introduction

This paper presents a System Dynamics model of the national system of primary and secondary education in Nicaragua. The model has been developed to support the National Ministry of Education of Nicaragua (MECD) in the preparatory phase of the process to take part in the first group of countries for the World Bank "Education for All" (EFA) Fast Track initiative[1]. The aim of the model is to serve as a tool, within this process of intensive planning, for the analysis of the costs and impacts of different possible policy measures and their combinations on the overall performance of the national system of education.

Background

The MECD of Nicaragua is the administrator of the national system of education, which includes preschool, primary school and high school. Given that nearly the 80% of the students at these three levels attend public schools, the MECD is the main provider of education for the country. At present, the educational system of Nicaragua has a coverage

[1] http://www1.worldbank.org/education/adultoutreach/index.efa.asp

of nearly 30% for preschool, 70% for primary school and 45% for high school. The average number of schooling years for the country is approximately five[2].

The main issue addressed in this study was to identify the policy and capacity gaps that will need to be resolved in order to meet the Millennium Development Goal of providing every girl and boy with quality primary education by 2015. The investigation should help to define which goals are reasonable (illiteracy rate, coverage of the programs, average schooling years), given the financial assistance that will be received, and to determine the best way to achieve these goals. A System Dynamics model was developed to support the Direction of Policy Research of the MECD in investigating these issues.

National educational system

The national educational system of Nicaragua is schematised in Figure 1. The two most important subsystems are demand and supply of education. The demand subsystem represents the demand for preschool, primary and high school, by the national population in all the different age ranges. The supply subsystem represents the installed capacity in terms of teachers and facilities. The top of the diagram presents the instruments or policy measures, e.g. subsidies for students, literacy programs and an increase of teachers' salaries, which can be implemented by the MECD to influence the system. The left hand side of the diagram shows external factors, which affect the performance of the system, but are not under the control of the MECD. Finally, the main performance indicators are shown on the right hand side of Figure 1. The performance indicators have been based on MECD plans (MECD, 2001a).

[2] Unless otherwise noted, the statistical data cited in the text was provided by the General Direction of Policy Research of the MECD.

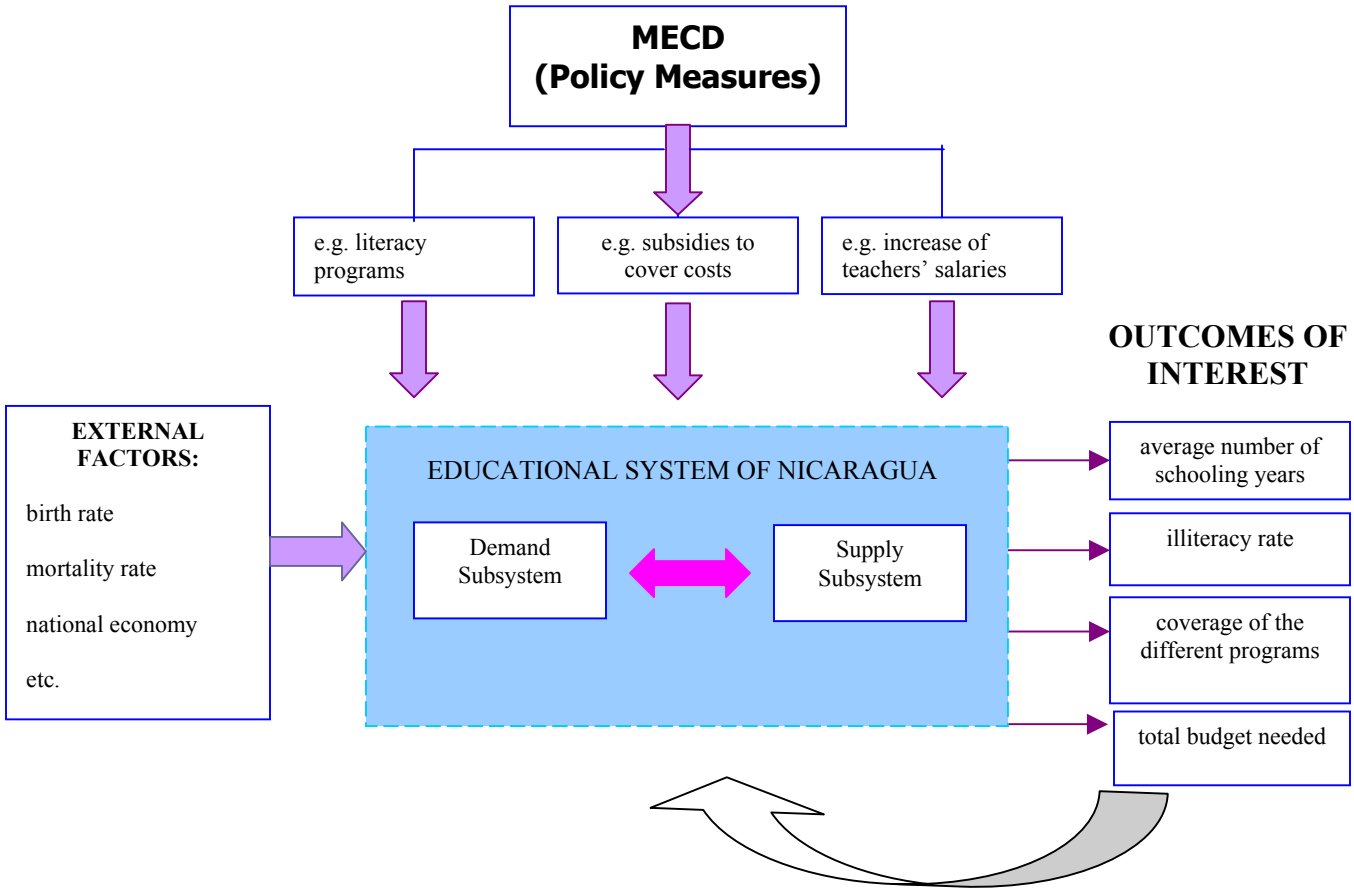

Figure 1. National educational system.

Related models on basic education

The national educational system of Nicaragua will be represented at a relatively high level of aggregation, simulating the flow of students throughout the whole educational system of the country from preschool to high school for both private and public education. The model aims to help the Ministry of Education to determine the costs of achieving certain goals and policies (policy and capacity gaps), which is key information in the process of negotiation within the international cooperation.

Various System Dynamics models that also analyse issues in basic education have been described in the literature (e.g. Karadeli *et al.*, 2001 and Terlou *et al.*, 1991). In models of educational systems, students move through a chain of classes. A certain percentage of children from the previous class enters a class each year, a certain percentage progresses from the current class to the next class and a certain percentage of children drops out of school each year. The way in which the percentages are determined, the level of detail contained in the model and the types of factors taken into account in each of these models depends on the questions to be answered by the model. The two most relevant other models will be discussed below and will be compared to the model of the situation in

Nicaragua. Following this, the model of the national educational system of Nicaragua will be described in more detail.

Karadeli *et al.* (2001) have developed a model to analyse the future quality of the Turkish basic educational system depending on the budget of the Ministry of National Education. In the model, students proceed through primary education and secondary education. This model distinguishes urban and rural school, and within the urban schools a distinction is made between public and private schools. For each of these different school types, the model looks at groups of girls and boys. The quality of education is determined by the student to teacher ratio and the student to class ratio. These ratios are also used to calculate the passage rates between classes. The number of teachers and the number of classrooms is calculated using the amount of money available for teachers and classrooms.

The main differences between the model by Karadeli *et al.* (2001) and the current model is that Karadeli *et al.* distinguish six different groups of students, whereas the current model is more aggregated with respect to these groups. A single group of students, which represents the national total, is considered, because the main question is how to reach the goal that every child should finish primary education, independently of the distribution. On the other hand Karadeli *et al.* (2001) have aggregated all classes in primary school into one stock, because in primary school in Turkey repetition is negligible. In the model described here, it is important to look at each of the classes in primary school because the characteristics with regard to repetition and progression are different (repetition rates are high 6 to 10%). Moreover, dropout rates are considerably higher in the first years of primary than in the following years, i.e. 11% in first grade vis-à-vis 7% in fifth grade. In addition, for the situation in Nicaragua it is also important to take into account literacy classes.

The model described by Karadeli *et al.* (2001) contains influences of the student to teacher ratios and the student to class ratios on the progression of students. In the model described here such a relationship has not been modelled. The students to teacher ratio has no influence in the dropout or promotion rates, because in principle the model is used to calculate the number of teachers required given a certain actual ratio, which has been assumed to be fixed at 40 for primary and high school. Thus measured by this indicator, the "quality" is assumed to remain the same.

Terlou *et al.* (1991) have developed a System Dynamics model to investigate the low efficiency of primary education in Latin America. The model looks at the progression through primary school and includes causal chains leading to the progression, dropout and repetition of students. A difference between the model by Terlou *et al.* (1991) and the model described here, is that the current model is geared specifically towards the national schooling system of Nicaragua, whereas the model by Terlou *et al.* shows one average chain of classes in Latin America. The current model is more aggregated than the model described by Terlou *et al.* (1991) in that the model by Terlou *et al.* represents the causes leading to dropout and repetition in some detail and in the current model these causal factors were not quantified. The dropout and repetition rates have fixed values (based on

historical data) that remain the same unless a new policy is implemented. Financial aspects and literacy classes are not included in the model by Terlou *et al.* (1991), but are important for the current model as they are part of the national schooling system.

In summary, the model described in this paper can be compared to the model by Karadeli *et al.* (2001) with respect to the level of aggregation i.e. of a national educational system. It can be compared to the model by Terlou *et al.* (1991) with respect to the types of problems it addresses, which are related to dropout and repetition rates.

System Dynamics model of the national educational system of Nicaragua

The System Dynamics model which been developed is based on the considerations that were mentioned above and consists of four main sectors: demand for education, supply of education, cost calculations, and calculation of performance indicators. These four sectors will be explained below.

A. Education demand

This subsystem generates the demand for education for all the age ranges and programs. The subsystem consists of an aging chain in which children move from one level to the next. Figure 2 shows that children stay at home for the first two years of their life, after which they can go to preschool at the age of three. Approximately 30% of children from 3 to 6 years attend preschool education, however only 10% of the children of 3 years old join the first level of preschool.

From the first level of preschool 80% of the children move on to the second level, and 20% drop out of school. At the second level, the children are joined by another group of children of four years old who did not attend the first level. Figure 2 also shows children proceeding through to the third level, from which they can then go onto primary school.

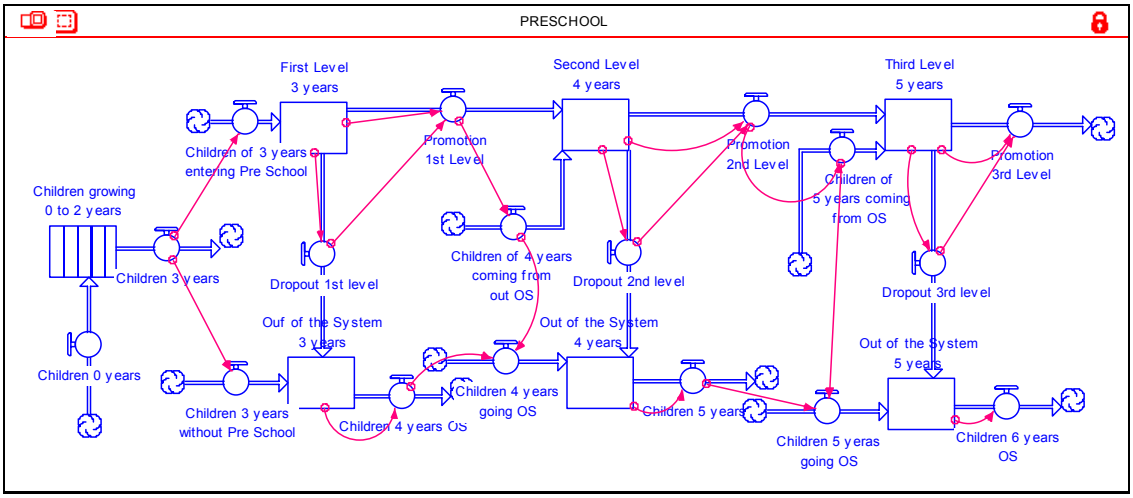

Figure 2. Children prior to preschool and in preschool.

Figure 3 shows the part of the model in which the children move through the first years of primary school. The percentage of children who drop out in the first year of primary school is higher than in the following years (MECD, 2001b). A difference between preschool and primary school is that some children have to redo a year, which has been included in the model. The children who drop out of primary school usually do not return and become functional illiterates after five or more years.

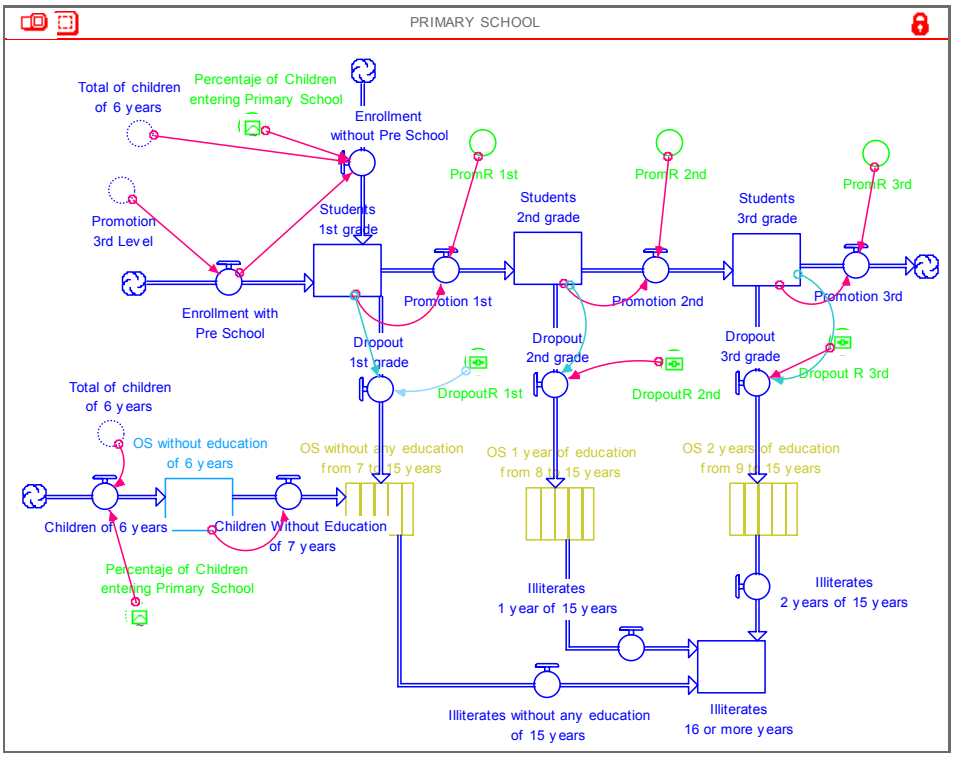

Figure 3. Part of the primary school section.

With this same logic flow all the children from six to twelve years pass through the educational system. A group, defined by the promotion rate which is approximately 90% of the children enrolled in 6th grade of primary school, moves on to the first year of high school, another group joins the labour force and the rest remains in the same class redoing the year. For high school, the flow of students has the same structure as the flow of students in primary school. Finally, a percentage of the students who finish high school continues studying and joins university.

B. Education supply: teachers and infrastructure

The education supply sector represents the installed capacity the MECD has to offer in response to the demand for free or public education. The body of teachers grows annually through hiring of new teachers and is assumed to decrease only with the retirement, which has been assumed to occur after approximately 30 years of service. In the case of primary and high school a distinction has been made between non-graduated and graduated teachers.

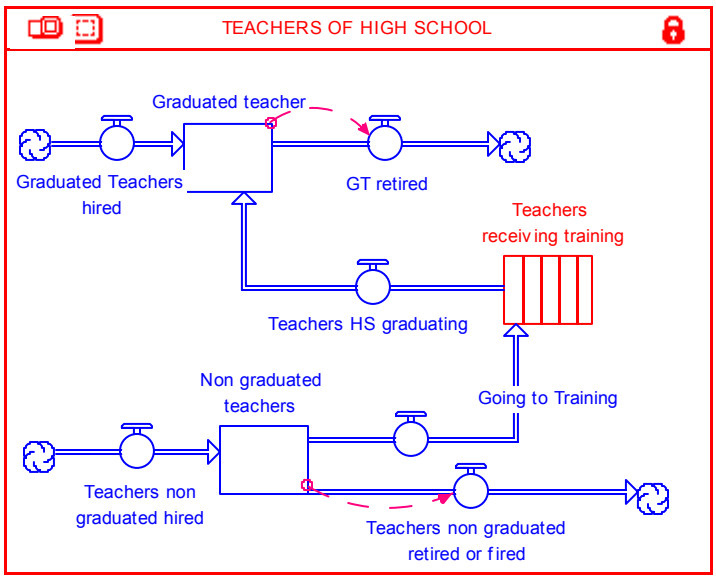

Figure 4. High school teachers.

The infrastructure component of this sector consists of the number of classrooms. The stock of classrooms increases annually with the construction of new ones and decreases when they reach the end of their useful life (see Figure 5). The average lifetime of a classroom is 10 years, but improved maintenance can increase the average useful life of a classroom up to 20 years [3].

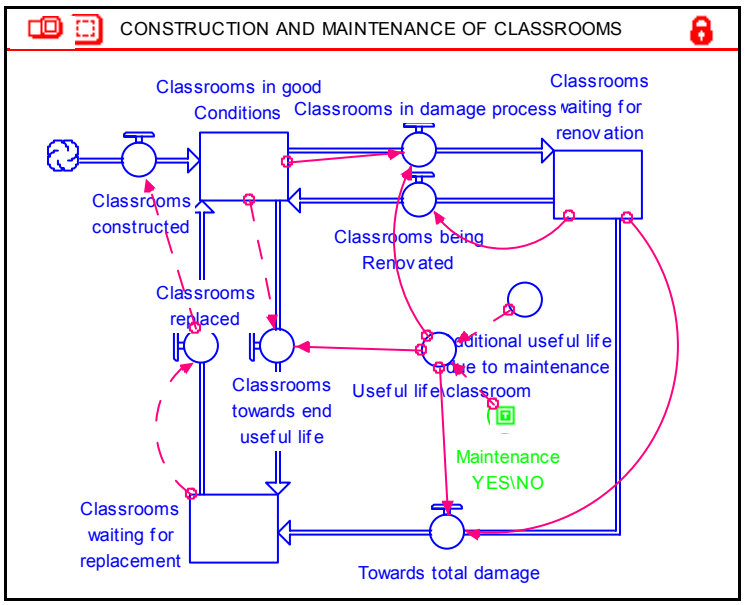

Figure 5. Infrastructure component of the model.

[3] Source: General Division of Investments and Cooperation, MECD.

C. COST CALCULATION SECTOR

This sector calculates the total budget, including operational and investment costs, needed to cover the demand for free or public education. Operational costs are calculated per program and for each program the most important factors consist of the number of students and number of teachers. Minimum standard costs per students are used, which includes books, tables, chairs and backpacks with notebooks (Franco, 2001).

It is important to highlight that the model is representative for the whole national educational system. Therefore, the demand subsystem includes the enrollment in private and public schools. However, within the cost calculation sector a distinction is made between the enrollment in public and private schools, given that it is the budget for only the public education sector that is calculated.

D. CALCULATION OF PERFORMANCE INDICATORS

This sector also represents a group of calculation processes. However, the indicators resulting from these calculations are representative of the performance of the whole national educational system and not only of public education.

The main performance indicators are the following:

- *Coverage per program:* is calculated taking into account the population inside and outside the program within the right age range.
- *Illiteracy rate:* reflects the percentage of people aged 15 and over who cannot, with understanding, both read and write a short, simple statement about their everyday life.
- *Average number of schooling years:* average number of years of schooling completed among the population aged 15 and older.

Model testing

Consistency checks and extreme conditions tests were applied to the model. Following these, a quantitative comparison was carried out for the demand sector and for the calculation of the performance indicators. For the other sectors (i.e. costs and supply of education), the data used in the model represent ideal parameters such as minimum standard costs and hiring of the teachers required. Therefore, a proper comparison with actual data cannot be carried out for these sectors. The main results of the comparison between the actual data and the values generated by the model, are shown in Appendix A.

In general it can be observed that there is a high degree of similarity between the actual values of the national education system and the values generated by the model. The differences in the enrollment percentages for preschool, primary and high school are of the order of 2 to 4%. Therefore, it can be assumed that the model shows a general behaviour representative of the behaviour of the real system it intends to simulate.

Model behaviour

The behaviour of the most important performance indicators (output criteria) are reviewed below for the medium (1998-2008) and the long-term (2008-2018). This

systematic review aims to increase the understanding of the overall performance of the system for the next 20 years when no additional policies are implemented.

Preschool coverage
The model shows an increase from 24% in 1998 to 30% in 2002, which is most probably due to the implementation and expansion of a program of community preschools. This program is more flexible and accessible to rural areas, than the formal way of working and is mainly based on teachers working voluntarily with no need for building classrooms. The actual enrollment of these community preschools increased from 24,000 children in 1995 to 100,000 in 2001 (UNICEF, 2001). From 2002 until 2018 the model shows that coverage remains stable at 30%. However, the absolute number of children enrolled increases in the model from approximately 160,000 in 2003 to 196,000 in 2018.

Primary school coverage
This performance indicator represents the percentage of children from 6 to 12 years of age who are receiving primary education. In the first two years there is an increase of 3%. From 2000 until 2008 a minor increase of 1% occurs and afterwards this remains stable with a coverage of 77%.

It is important to mention that the improvement of coverage for the first years could be overestimated due to the fact that there were no accurate statistics on the number of children who are not in school and thus the initial values had to be extrapolated. However this does not present a problem because from 2001 onwards the model does keep accurate accounting of the children out of the system.

Primary school relative coverage
This performance indicator differs from the previous one in that it represents the percentage of the total number of children from 6 to 15 years who cannot participate in any other education program than primary school. This new group includes the children who, although they are older than 12 cannot attend high school because they have not finished primary school and cannot yet take part in literacy programs due to their age. Therefore this indicator represents the magnitude of the challenge for the primary education subsystem more realistically. After 2000 this indicator remains constant at 68%, which is 9% less than the coverage estimated by the previous indicator.

In terms of the absolute number of children enrolled in primary school, there is in increase of 80,000 children in the first 10 years and of 89,000 in the last 20 years.

High school coverage
This indicator represents the percentage of the total number of children between 13 and 17 years of age within the high school educational system. As can be seen in Figure 6, the improvement of primary coverage of 3% that occurred in the first 2 years has an effect on the coverage of high school in 2005. Afterwards the coverage only improves by 1%, remaining stable at 49% from 2010 onwards.

High school relative coverage

As was the case for the primary school relative coverage, this indicator aims to calculate the real gap faced by the high school subsystem. Therefore it represents the percentage of the children between 13 and 17 who have completed their primary education. Figure 6 shows that after an improvement of 6% from 1998 to 2004, coverage remains at 73% until 2018. Thus, measured in this way, high school shows a performance similar to primary school which showed a coverage of 77%.

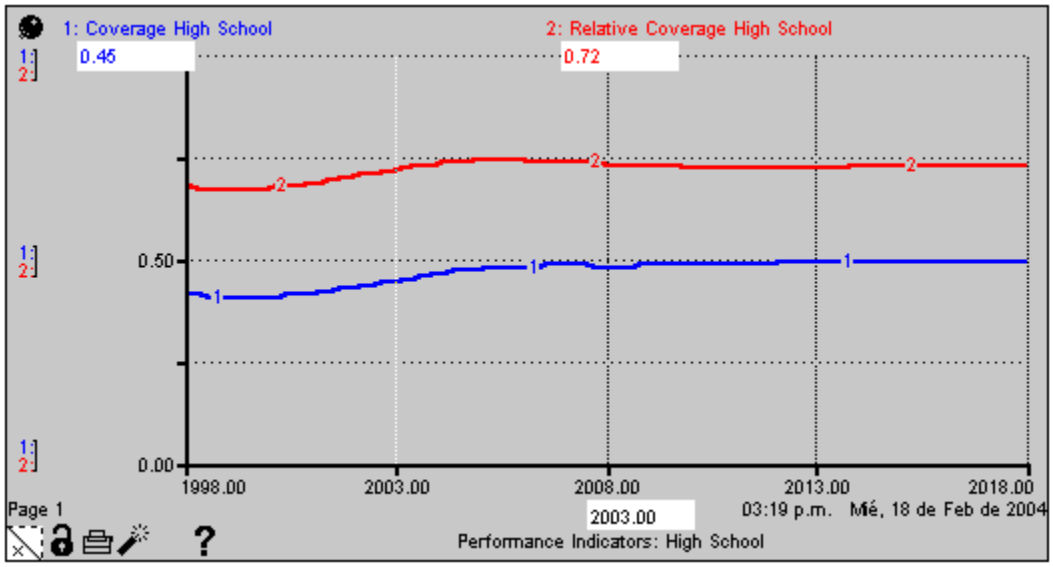

Figure 6. Performance indicators: high school.

Illiteracy rate

If no literacy program is implemented the illiteracy rate tends to increase, as could be expected. From 1998 to 2000 the illiteracy rate increases by 2% and it increases by 1% from 2003 onwards and reaches a value of 30% (Figure 7).

Total number of illiterates

Even though an increase of only 3% in the illiteracy rate does not seem dramatic, when looking at the actual number of illiterate people the increase does show a serious problem. The number of illiterate people increases from approximately 640 thousand in 1998 to 1.11 million in 2008 and accounts for 1.54 million in 2018 (Figure 7). This means that the initial number more than doubles, and there is an annual increase of approximately 45 thousand illiterate people.

Figure 7. Performance indicators: illiteracy.

Average number of schooling years

As shown in Figure 8 the average number of schooling years increases from 4.6 in 1998 to 5.8 in 2018, which is still under the average of 6 years that Costa Rica reached in 2000, and under the average of 6.2 years that Chile had already reached in 1960 (UIS/OECD, 2002). However, the curve does not show exactly the same slope throughout the years. It is somewhat steeper from 1998 until around 2012, which could be due to the improvements in the first years 5 years in the coverage of the different regular programs. Afterwards it shows the tendency to flatten out, which means that significant increases of this indicator cannot be expected later on.

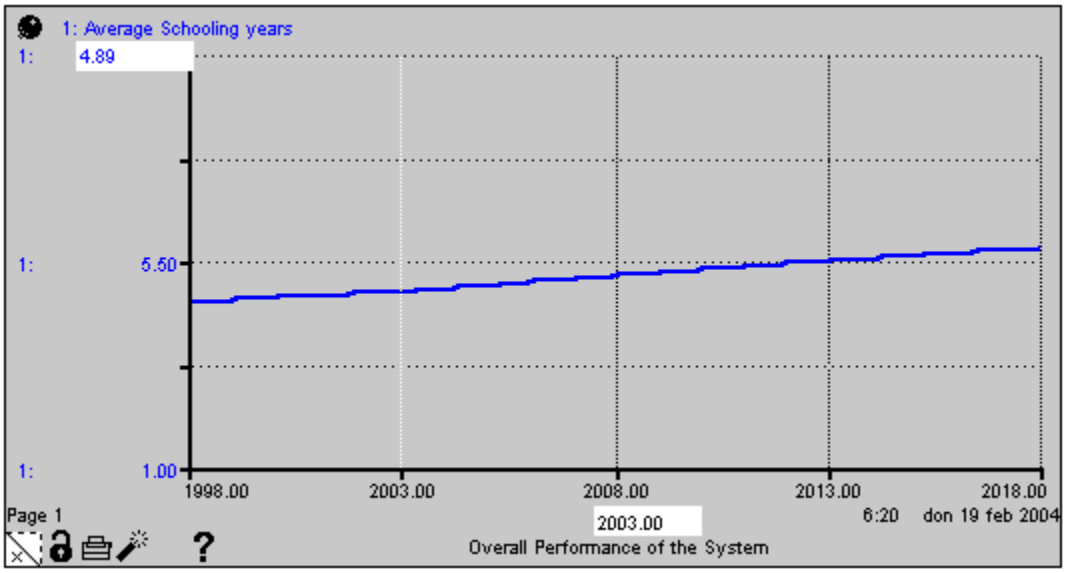

Figure 8. Performance indicators: average number of schooling years.

From the review of the behaviour of the performance indicators of the model some important observations can be made:

- *Primary school*: even if 100% of the children of 6 years of age enrolls in primary school, with the current dropout rates, the overall coverage of primary school will never reach 100%. Therefore, the dropout rates should be considered important leverage points for further improvement of system performance.
- *High school*: the new indicator high school relative coverage, which is not a commonly used indicator but is included in the present model, allows us to observe that this subsystem has a real performance very similar to the primary school subsystem. However, a significant improvement in the effectiveness and coverage of primary school, which now represents a bottleneck, would require an enormous expansion of high school capacity in order to maintain the actual performance.
- *Illiteracy*: the illiteracy rate in itself is not sufficient as an indicator of the illiteracy problem in a country. The value of 2.4 times the initial number of illiterate people is evidence of the chronic problem of the educational system, especially in primary schools where the dropout rates are particularly high.

The performance of the system discussed above will be considered to be the zero option for the comparison of alternative policy measures that will be presented in the following section.

Investigating the impact of different policies

The impact of two different policy options will be studied below. The first policy consists of intensifying literacy programs, and the second consists of providing a subsidy to cover the opportunity costs of parents when their children go to school.

Policy option 1: Literacy programs

Literacy programs aim to alleviate the illiteracy problem by implementing a three year course for functionally illiterate people who are over the age of 15 years. Literacy programs in Nicaragua started only recently (in 1998). Present enrollment is quite low, but efforts in this direction could be stepped up.

The MECD is considering proposing a target of 50 to 60 thousand people a year to graduate from the literacy program to the international cooperation, with the aim to solve the illiteracy problem by the year 2015. The graduation target corresponds to an enrollment number of around 60 thousand people each year in the first level. This means that the enrollment of the three levels should make up a total of around 180,000 people receiving education within the literacy program. The implementation cost of this policy is estimated at around 8 to 9 million US dollars per year.

In the current model, a literacy program does not show any impact in the performance of preschool, primary and high school education. It is important to mention that in reality there does seem to be an influence of the level of education of the parents on the assistance of children and their performance in school, which has been widely mentioned in previous studies. A review of 67 research studies on literacy programs (Padak and

Rasinski, 1997) found that as parents spend time in adult literacy programs, their attitudes towards education change: the more literate they become, the more value they perceive in education, the more they support their childrens' learning and the more they become involved in their childrens' schools. The result is that their childrens' school achievement jumps (Padak and Rasinski, 1997). The same report found that as parents continue to spend time in literacy programs, their children attend school more regularly, achieve higher IQ scores, and are more likely to complete their education. Moreover, the results of a set of comparative tests applied around 1990 to measure the academic achievement of Latin American students showed that children whose parents have a low educational level score poorly on all these tests (UNESCO/OREALC, 2000). The scores obtained by children who took the UNESCO/OREALC test increased by 1.1 points for every additional year of their parents' education. However, this feedback effect was not included in the model, given that the statistical data available did not allow for a proper quantification of this relationship in the model. This should be taken into account when interpreting the model results.

Illiteracy

When introducing the literacy policy, the model shows a significant improvement of the illiteracy rate from 30% in 1998 to 21% in 2008 and 15% from 2017 onwards (Figure 9). When compared to the base situation the illiteracy rate is 16% less when the literacy program is implemented. This improvement is significant compared to the literacy indicators for the other Latin American countries from 1980 to 2000. Most of the countries show an improvement of 2 to 3% per year. The only two countries that show a comparable improvement in 10 years, are Brazil and Peru, which show a decrease of around 7% in the illiteracy rate from 1980 to 1990 (UNESCO, 1995).

As expected, the number of illiterate people also decreases vis-à-vis the situation when no policy is implemented. Under this policy the number of illiterate people reaches a value of approximately 610 thousand in 2018, which represents 930 thousands less than for the zero option.

However, it should be mentioned that when compared to the number of illiterate people in 1998, which accounts for around 640,000, the situation does not seem to improve as much as expected. The actual reduction is only around 30,000 persons in 20 years, even though as shown in Figure 9, approximately 790,000 persons finish the literacy program in the same period of time.

This policy is effective in decreasing the illiteracy rate and shows a significant improvement compared to the base situation, but only this measure is not enough to achieve the improvements aimed with the EFA plan. As can be seen from the figures presented above, this program can ameliorate the illiteracy problem but will not eradicate it unless the actual efficiency of the basic education system improves.

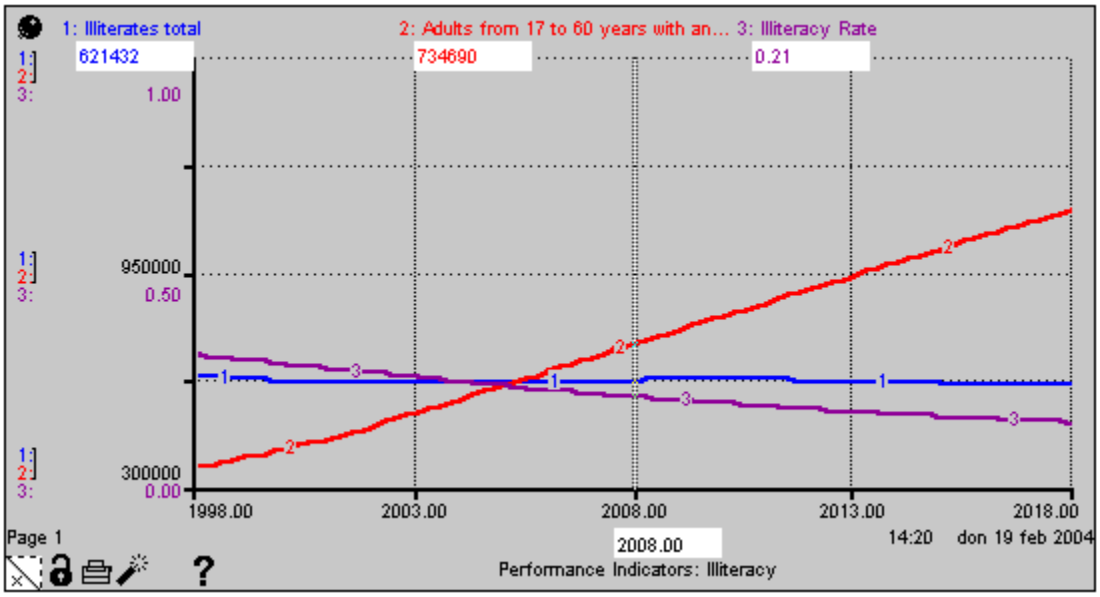

Figure 9. Illiteracy indicators when the literacy policy is implemented.

Average number of schooling years
The literacy policy causes an increase in the average number of schooling years from 4.6 in 1998 to 6.3 in 2018. Compared to the base case this means an improvement of half a year in the overall average of the country.

Policy option 2: Subsidy to cover the opportunity costs

This policy intends to prevent children from dropping out of school and in this way to ensure that a larger percentage of school-age children attend school. As stated by the USAID Office of Women in Development (USAID, 1997), an important barrier for a total coverage of the primary education is the cost of schooling, which is often prohibitively expensive for families in poverty. In addition to paying for their daughters' books, clothing, and other costs, parents must factor in the foregone income from the child earning a wage or helping out with household tasks.

In Brazil a program, called Bolsa-Escola, which provides financial assistance to parents has been in place since 1995. This program consists of granting a monthly allowance to families with children aged 7 to 14 and an average family income below that of the average state income, as long as the parents keep their children in school. With approximately 8 million children being beneficiated each year, Brazil has come very close to fulfilling the basic principle of making education universal. In 1999, 96% of all children aged 7 to 14 were attending school, compared to 89% in 1994[4].

A similar program has been implemented in Guatemala. This country has been a leader in offering scholarships to keep indigenous girls in school (USAID, 1997). USAID's Basic Education Strengthening (BEST) Project built on earlier efforts to provide scholarships

[4] Providing Universal Education, Embassy of Brazil in London, 2004. Website: http://www.brazil.org.uk/page.php?cid=504

and to evaluate the effect of these scholarships on girls' school dropout rates. When local community workers assisted parents' organizations in providing scholarships for girls, the first grade promotion rates for scholarship recipients were at least 20 percentage points higher than for non-scholarship recipients over a three-year period. In 1996, for example, 87.5 percent of the girls in the scholarship program went on to second grade, as compared to 61.9 percent of a control group of girls who did not receive scholarships (USAID, 1997).

The policy which was investigated using the model, consists of giving a monetary subsidy equivalent of 100 US dollars to the parents of children in risk of leaving primary school due to poverty reasons. This is equal to the subsidy received by the Brazilian families under the Bolsa-Escola program mentioned above. The national Nicaraguan census of 1998 shows that 19.6% of the children who are actually in the educational system live in extreme poverty (EMNV, 1998). This group of children is considered to be the target group for the present policy. The results to be presented correspond to the impact of the policy when 30% of these children receive the subsidy. An important assumption in the model is that when assigning the subsidy, students from first to sixth grade are prioritized in ascending order. The program is assumed to be successful in 30% of the cases, given that in some cases it does not succeed in retaining the students at school or the subsidy is assigned to children who would continue studying anyway. This percentage of success of 30% is considered comparable to the success of the Brazilian program.

The resulting costs of the implementation of the program are also estimated to amount to approximately 8 to 9 million US dollars per year. The direct costs of the subsidy program amount to four to five million dollars and the remainder goes towards the additional operational costs of the primary program due to the increase in enrollment. Moreover, the capacity needed to accommodate this growth in enrollment means around three thousand more teachers and classrooms compared to the base case, and around ten thousand more than the actual capacity. This seems a major challenge when analysing the causes of the actual deficit of teachers the educational system faces presently. Until now an increase of 800 teachers per year has been necessary, but has not been realized because the budget is insufficient. Moreover, covering the teacher deficit, even when enough money would be available, would mean a higher proportion of non-graduated teachers. The teacher training colleges are not educating/graduating enough teachers per year. The colleges are being used to only 50% of their total capacity because there is not enough budget to cover scholarships and there is not enough demand. Increasingly fewer high school students choose a teaching profession due to the low socio-economical status of teachers and the low salaries. The monthly salary amounts to only 70 American dollars for primary school teachers and 150 for high school teachers.

Primary school coverage

Unlike the literacy policy, the subsidy does have a direct impact on the coverage of primary and high school, which can be seen in Figures 10 and 11. The coverage of primary school increases from 73% in 1998 to a maximum of 83% from 2009 onwards

(Figure 10). Compared to the base case this represents an improvement of 6% which also holds for the indicator of relative coverage.

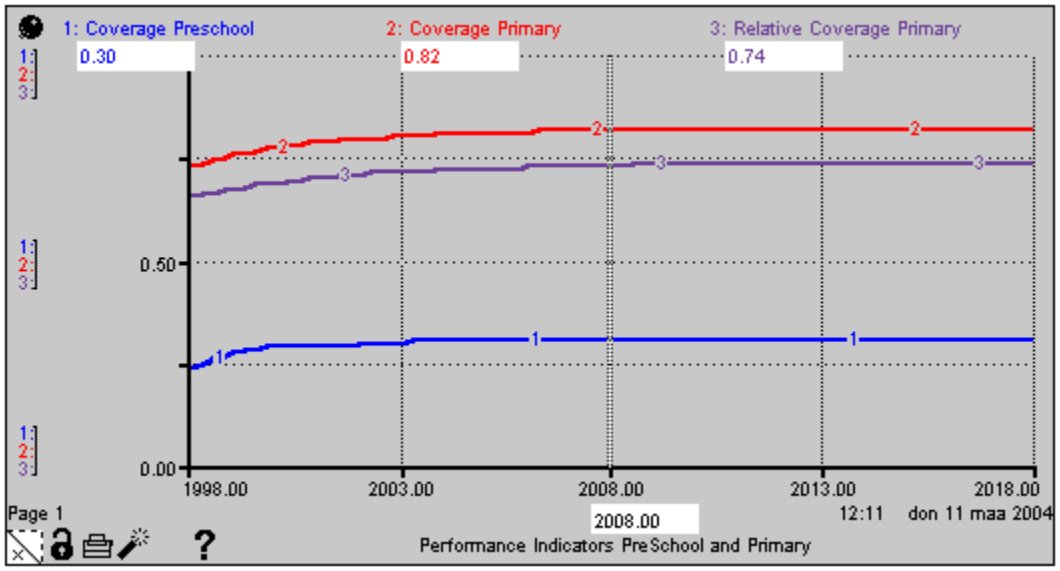

Figure 10. Coverage of preschool and primary school when the subsidy policy is implemented.

High school coverage

The coverage of high school, as shown in Figure 11, reaches a maximum of 53%. This corresponds to an improvement of approximately 4% with respect to the maximum of 49% coverage in the base case. However, the indicator of relative coverage does not show any improvement when compared to the zero option. This shows that the policy indeed did not affect the internal efficiency of the high school subsystem, in which dropout rates remain the same.

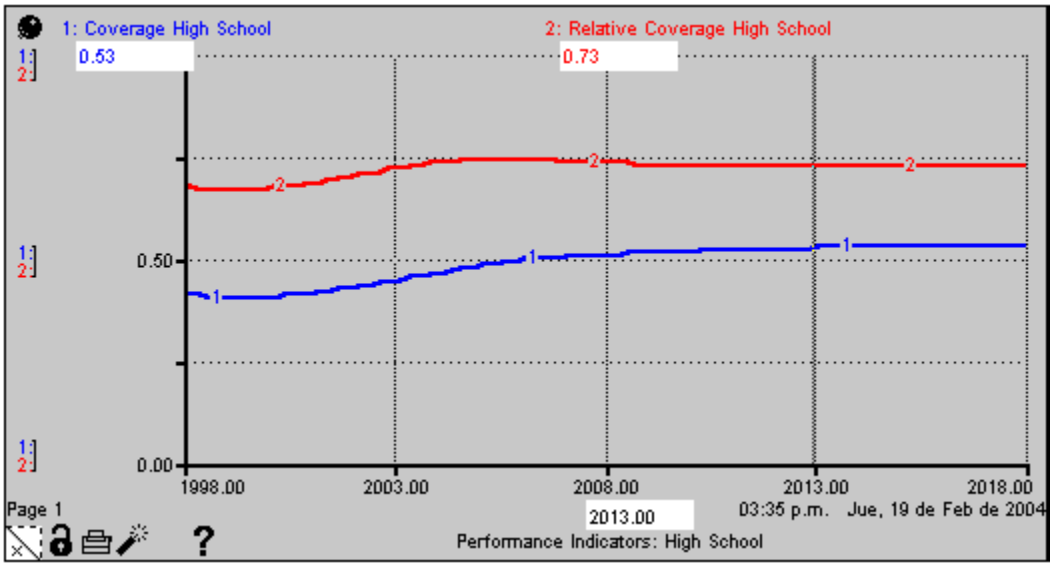

Figure 11. Coverage of high school when the subsidy policy is implemented.

Illiteracy rate

The illiteracy rate shows an improvement of 2% when compared to the base case, which means an increase of 1% compared to the initial value of 27% (Figure 12). Similarly the magnitude of the illiterate population shows an improvement of only approximately 120 thousand people when compared to the base case.

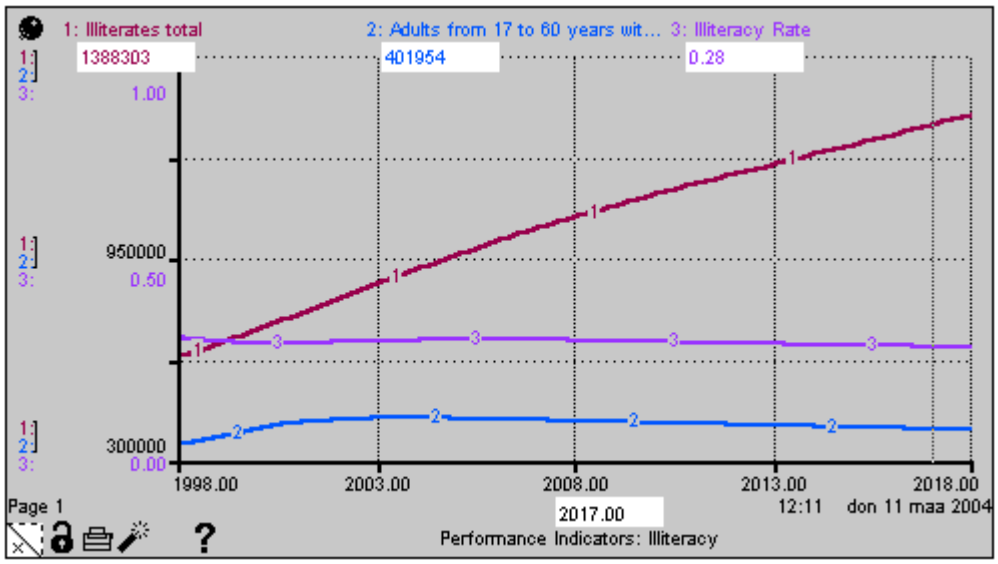

Figure 12. Illiteracy rate when the subsidy is implemented.

Average number of schooling years

The implementation of the subsidy to cover the opportunity costs has an impact on the average number of schooling years of just one fifth of a year more than when no policy is implemented.

Table 1 shows a summary of results for different variations of the subsidy policy. The number of students to receive a subsidy was altered as well as the effect of the subsidy on the children remaining in school.

Table 1. Performance indicators for a number of alternatives in the implementation of the subsidy policy.

Effect by Year 2018	Preschool Coverage	Primary		High School	
		Coverage	Relative C	Coverage	Relative C
No Policy	30%	77%	69%	49%	73%
Subsidy (30%+30%effect)	30%	83%	75%	53%	73%
Subsidy (60%+30%effect)	30%	89%	81%	57%	73%
Subsidy (60%+40%effect)	30%	92%	86%	60%	73%
Subsidy (100%+40%effect)	30%	96%	90%	64%	73%
Subsidy (100%+100% effect)	30%	100%	100%	73%	73%

Effect by Year 2018	Illiteracy		Average Schooling Years	Additional cost per year (US$)
	Rate	Total Illiterates (million)		
No Policy	31%	1.5	5.8	
Subsidy (30%+30%effect)	28%	1.4	6.0	9 million
Subsidy (60%+30%effect)	25%	1.3	6.3	18 million
Subsidy (60%+40%effect)	23%	1.1	6.5	22 million
Subsidy (100%+40%effect)	20%	1	6.8	37 million
Subsidy (100%+100% effect)	18%	0.9	7.3	40 million

Combining literacy programs and subsidies to cover the opportunity costs

As the results of the two different types of policies (i.e. literacy programs and providing financial assistance to poor families) show, it is not possible to judge one of the policies as performing better than the other. It seems that each has a positive effect on different factors of the education problem and neither of these alone improves the overall performance of the educational system.

For this reason, the model was run to simulate the impact of both policies at the same time. Table 2 presents the performance of each of the two policies, as well as the performance of both policies when implemented at the same time. The numbers in the table are shown relative to the base case. As can be seen from the results, the implementation of both policies does achieve an improvement in all the performance indicators.

Table 2. Relative performance of policies compared to base case for the year 2018.

Effect by Year 2018	Preschool Coverage	Primary		High School	
		Coverage	Relative C	Coverage	Relative C
Literacy	0%	0%	0%	0%	0%
Subsidy (30%+30% effect)	0%	6%	6%	4%	0%
Literacy & Subsidy	0%	6%	6%	4%	0%
Subsidy (60%+30%effect)	0%	12%	12%	8%	0%

Effect by Year 2018	Illiteracy		Average Schooling Years	Cost per year (US$)
	Rate	Total Illiterates (million)		
Literacy	-16%	-0.9	0.5	9 million
Subsidy (30%+30%effect)	-3%	-0.1	0.2	9 million
Literacy & Subsidy	-19%	-1	0.7	18 million
Subsidy (60%+30%effect)	-6%	-0.3	0.5	18 million

Conclusions and discussion

An aggregated model of the educational system of Nicaragua was developed in order to support the National Ministry of Education (MECD) in identifying and analysing the consequences of policies that are aimed at improving the coverage of the different educational programs, reducing illiteracy and increasing the average number of schooling years of the population. The model shows that without a change in policy there will only be a small increase in the percentage of primary and high school coverage and that the number of illiterate people will more than double over a period of twenty years. The consequences of various policies have been investigated using the model. The two policies that were studied in the current analysis consisted of intensifying literacy programs and introducing a program in which families in extreme poverty receive a subsidy to cover the opportunity costs of their children when they go to school.

The model shows that the education problem in the country has many components and therefore a combination of different policy measures seem to be necessary in order to solve the problem of different target groups. In addition, the effectiveness of each of the educational programs influences the performance of the other subsystems. In this respect, the effectiveness of the basic education system (primary education) showed to be key for a sustainable improvement of the illiteracy problem as well as for a higher performance of the high school program. Dropout rates in primary school showed to be important leverage points for a significant improvement of the education system as a whole. Therefore, further research of policies, such as the subsidy to parents, that aim to directly influence these rates, is needed.

More information and understanding of the retention and promotion functions in primary school is required in order to obtain a more accurate evaluation of the policy alternatives. A better understanding and quantification of the factors affecting these rates would allow the incorporation of feedback effects of the different policies in the model. One feedback effect that has been widely mentioned in the literature and deserves special attention is the relationship between the education of the parents and the probability of children dropping out of school. The question is how the positive effect of literacy programs on the drop out rates of primary school and vice versa can be measured. This effect has not been included in the present model, but it could have a significant effect on the behaviour of the model with respect to retention rates in school. It would mean that the results of the literacy programs would not only influence the number of illiterate people but also have an influence on the drop out rates in schools.

To conclude, it is important to mention that this paper aims to call for suggestions for further enrichment of the model and for ideas on the most accurate ways to model policy initiatives and measure their feedback in the educational system.

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Appendix A. Quantitative comparison

DEMAND FOR EDUCATION			
Source:	Unless otherwise noted, the statistical data cited was provided by the General Direction of Policy Research of the MECD		
Variable	Year	Actual value (*1000)	Value calculated by the model (*1000)
Total Pre-School enrollment	2000	167	159
	2003	179	160
Coverage of Pre-School	2003	30%	30%
Total Primary enrolment	2000	838	870
	2001	867	893
Total High School enrolment	2000	315	307
	2001	335	328
Total Population	2000	5,072	5,105
	2002	5,342	5,391
Illiterates	2001	715	729
CALCULATION OF PERFORMANCE INDICATORS OF THE EDUCATION SYSTEM			
Source:	Human Development Report 2003. UNDP. www.undp.org		
Indicator	Year	Value	Value calculated by the model
Adult literacy rate (% age 15 and above)	2001	69.1%	71%
Combined primary, secondary and tertiary gross enrollment ratio	2001	65%	68%
Source:	Official Presentation, MECD: "Estado de la formación de la ciudadanía y Recursos Humanos", MECD II. La Educación en Nicaragua Diagnóstico a lo Interno del Sistema Educativo http://www.mecd.gob.ni/educ.as		
Indicator	Year	Actual value	Value calculated by the model
Average schooling years	2003	5 years	4.9 years

Population without a complete High School Education (from 18 to 45 years)	2003	1,435 thousand (71.5%)	1,488 thousand
Source:	Education Indicators 2000, Nicaragua, Ministry of Education, Culture and Sports (MECD) http://www.mecd.gob.ni/		
Indicator	Year	Actual Value	Value calculated by the Model
Coverage of Pre-School	2000	27%	29%
Coverage of Primary	2000	80%	76%
Coverage of High School	2000	43%	41%
Source:	Official Presentation, INATEC (National Institute for Technical Education): System of Technical Agricultural Education and Training (SETAC) http://www.senar.org.br/seminario/ppt/Luz%20Marina/d)%20lUZ%20MARINA-EPT-2-2003.ppt		
Indicator	Year	Actual value	Value calculated by the model
Average Schooling years	2003	4.8 years for men 5 years for women	4.9 years

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