Flow Modelling of the Educational System Using Dynamo Method

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Abstract-*This article proposes to model and identify the educational system using modelling dynamo in the stock-flow approach initiated by Forrester. The method is to model a level of schooling and determine its step and impulse responses. Model of one cycle is obtained by cascading levels which make it up. The system model is obtained by the cascading of the cycles which make up. For analyzing the impulse response of a school level, a known number of students is injected into the corresponding tank as initial value. The simulation process allows seeing how the level of the tank evolves with respect to time. During this simulation, Inflow is maintained disabled. For the step response is the inflow which is maintained at a constant value. Tank is initially empty. The flow parameters used in modelling are: the promotion rate, repetition rate, and dropout rate. In reality, these parameters depend on time and on some other factors. To simplify the analysis and identification, it's the average values of these parameters that are taken in the simulation process. After cascading, the overall model allows to visualize the response of the system in respect of different values of the flow parameters, so that makes it possible to explore by simulation the behaviour of the system in response to a given policy decision.*

Keywords- *system; modeling; simulation; approach; Forrester; education; educational; complex; dynamic; Flow; Stock*

1 INTRODUCTION

Compared to other socio-economic sectors, educational development involves more complex and multidimensional problems [1]. The management of an educational system consists in coordinating the flow of students between different levels in different educational cycles while ensuring optimal distribution of human and material resources in accordance with the educational objectives expected by the system. But the difficulty is to predicate the system comportment in response to a given education policy. Flow parameters represent the dynamic characteristics of the system and also represent indicators of its internal performances; that is to say, its fluidity (repetition rate), its attractiveness (dropout rate) and efficiency learning (promotion rates) [2]. These parameters are used to calculate, from the number of newcomers in an education cycle, the distribution of students in each level. Requirements in education be it personal, instructional material, and infrastructure for an education cycle are determined from the Grade-specific enrolment which is the total of students enrolled in this cycle [3].

2 DETERMINATION OF FLOW PARAMETERS

Students in a given grade level are distributed at the end of a school year into three categories:
1) Students who have acquired the necessary skills to allow them to move to the next level. 2) Students who haven't acquire these skills and must remain at the same grade level. 3) Students who leave the system for various reasons.
At the beginning of the school year, one grade level receives students promoted from the lower level that must join the repeaters already schooled in this grade level. Mobility rates are rate of promotion, of repetition and of dropout. These rates depend on several internal and external factors of the system. The arrow diagram in (Figure 1: Arrow Diagram of flows) shows the development of enrolments E_i in grade level i during a transition ($t_k \Rightarrow t_{k+1}$) depending on flow parameters at a given time t_k . Equations (1) and (2) are deducted from this diagram.

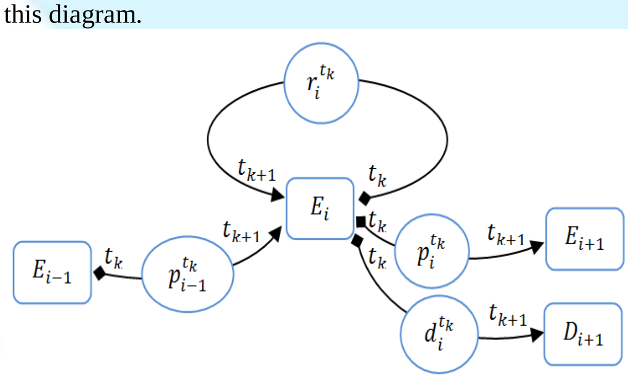

Figure 1: Arrow Diagram of flows

$$\begin{cases} E_i^{t_{k+1}} = p_{i-1}^{t_k} * E_{i-1}^{t_k} + r_i^{t_k} * E_i^{t_k} & (1) \\ E_i^{t_k} = r_i^{t_k} * E_i^{t_k} + p_i^{t_k} * E_i^{t_k} + d_i^{t_k} * E_i^{t_k} & (2) \end{cases}$$

$r_i^{t_k} * E_i^{t_k} = E_i^{t_k} - p_i^{t_k} * E_i^{t_k} - d_i^{t_k} * E_i^{t_k}$

$E_i^{t_{k+1}} = p_{i-1}^{t_k} * E_{i-1}^{t_k} + E_i^{t_k} - p_i^{t_k} * E_i^{t_k} - d_i^{t_k} * E_i^{t_k} (3)$

$$E_i^{t_{k+1}} = [E_i^{t_k}] + [p_{i-1}^{t_k} * E_{i-1}^{t_k}] - [E_i^{t_k} * (p_i^{t_k} + d_i^{t_k})]$$

$E_i^{t_{k+1}}$ *: Actual value,* $E_i^{t_k}$ *:Previous value*

$p_{i-1}^{t_k} * E_{i-1}^{t_k}$*:Inflow line,* $E_i^{t_k} * (p_i^{t_k} + d_i^{t_k})$*:Outflow lines*

The change made during transition t_k to t_{k+1} is resulting by difference between inflow materialized by students promoted from lower level, and outflow materialized both by line of students in the level i who left school during the latest year, and line of student promoted to the next level (i+1) for the next school year (t_{k+1}). This transition can be represented by a Stock-Flow diagram according to Forrester principle[4], where a school level is schematized by tank, flows by valves, and where flow rates are the decision variables (Figure 2).

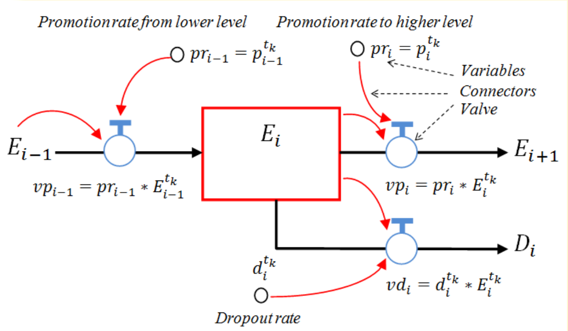

Figure 2: Dynamo model of a grade level

In what follows, grade level is characterized by its flow parameters. These parameters depend on time, on level, and on some other factors(Figure 3). Therefore, it is difficult to accurately predict the values of flow parameters. Flow parameters are not directly accessible. To reduce the dropout rate, it is necessary to identify and minimize its risk factors, and for increasing the promotion rate it is necessary to identify and promote the success factors.

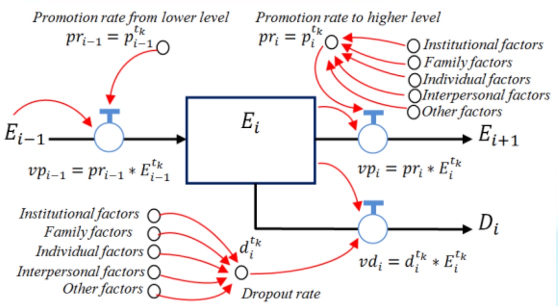

Figure 3: Dynamo model with influence factors.

The National Dropout Prevention Center/Network-Clemson University, has published a synthesis report of several publications about 'Risk Factors for School Dropout[5]. In which 25 risk factors for dropout are identified (Table 1:Significant Risk Factors by School Level). In order to synthesize, we suggest classifying these factors into four groups: Institutional, family, individuals and interpersonal (Figure 3). Two ways are possible to make feasible simulation process, if it has a sufficient history about these parameters then it's possible to take for each of the flow parameters, the average observed about grade level considered, else the last year for which there is enough school information, is considered as a reference year t_0 in the simulation process, and flow parameters taken in account, are parameters of this year[6].

Table 1:Significant Risk Factors by School Level

Risk Category and Risk Factor	Primary school	Middle school	High school
Individual Background Characteristics			
• Has a learning disability or emotional disturbance		v	v
Early Adult Responsibilities			
• High number of work hours		v	v*
• Parenthood			v*
Social Attitudes, Values, & Behaviour			
• High-risk peer group		v*	v
• High-risk social behaviour		v*	v
• Highly socially active outside of school			v
School Performance			
• Low achievement	v*	v*	v*
• Retention/over-age for grade	v*	v*	v*
School Engagement			
• Poor attendance	v*	v*	v*
• Low educational expectations		v*	v*
• Lack of effort		v	v
• Low commitment to school		v	v*
• No extracurricular participation		v	v*
School Behaviour			
• Misbehaviour	v	v	v*
• Early aggression	v	v	
Family Background Characteristics			
• Low socioeconomic status	v*	v*	v*
• High family mobility		v*	
• Low education level of parents	v	v	v*
• Large number of siblings	v		v
• Not living with both natural parents	v	v	v*
• Family disruption	v		
Family Engagement/Commitment to Education			
• Low educational expectations		v*	
• Sibling has dropped out		v	v
• Low contact with school		v*	
• Lack of conversations about school		v*	v

*Key: **v**indicates that the risk factor was found to be significantly related to dropout at this school level in one study. **v***indicates that is was found to be significantly related to dropout at this school level in two or more studies.

3 IDENTIFYING A GRADE LEVEL

For identification, we take as a support actual values of data and parameters identified in 2003, relating Moroccan educational system state at this year for which we have enough information. In what follows, year 2003 is considered as reference year for which the Baseline data related to first grade level is summarized in (Table 2).

Table 2: Baseline data at year 2003

Newly enrolled in 2003 (2002-2003)*	587976
Total enrolled in 2003 (2002-2003)*	740582
Promotion rate p_1^{2003}	75,30%
Dropout rate d_1^{2003}	07,90%
Repetition rate r_1^{2003}	16,80%

* *Source: Statistical Yearbook 2005*[7]

3.1 Impulse response of a grade level:

Here we assume that this grade level is loaded by the initial number of students (740582) in only once at (to=2003), and then it is left to itself.

Table 3: Impulse response results

In 2003→2004, $E_i = 740582$ (Initiale value) $p_i = 75{,}3\%$ $d_i = 7{,}9\%$ $(vp_{i-1} = 0)$				
Step-time	Inflow	Tank	Outflow Promote	Outflw Dropout
Année t_k	vp_{i-1}	E_i	vp_i	vd_i
$t_0 = 2003$	0	740582	557658	58506
$t_1 = 2004$	0	124418	93687	9829
$t_2 = 2005$	0	20902	15739	1651
$t_3 = 2006$	0	3512	2644	277
$t_4 = 2007$	0	590	444	47
$t_1 = 2008$	0	99	75	8
$t_2 = 2009$	0	17	13	1
$t_3 = 2010$	0	3	2	0
$t_4 = 2011$	0	0	0	0

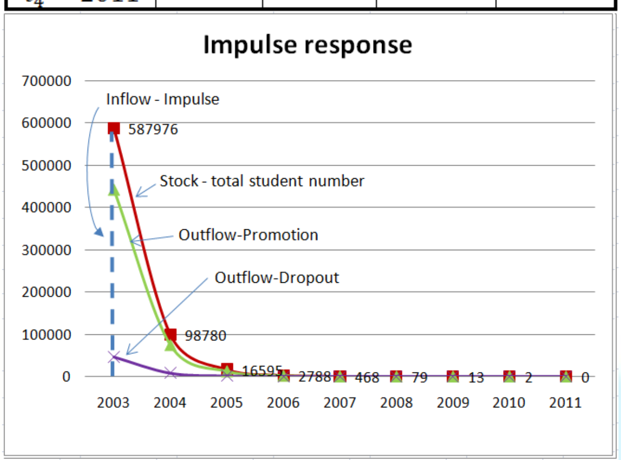

Figure 4: Impulse response for a grade level

The grade level initially loaded by (740582) pupil takes eight years to become completely empty. The fact that such number of pupils stay in first grade for so long, shows that the Moroccan educational system was not enough fluid in 2003 with this configuration. To increase the system fluidity, outflows lines must increase: promotion rate (and / or) dropout rates. Such fluidity can be improved by increasing the promotion rate, that's to say by increasing system effectiveness, by increasing the dropout rate also, and by decreasing the system of attractiveness. This implies that the increase of the fluidity of the system does not always mean improve its quality.

3.2 Step response:

Here we assume that the first grade level is initially empty and it is loaded every year by a constant number of students. The real value of newly enrolled into Moroccan system at year 2003 is taken as 'step amplitude'.

Table 4: Step response calculating

En 2003→2004, $E_i = 0$ (Initiale value) $p_i = 75{,}3\%$ $d_i = 7{,}9\%$ $(vp_{i-1} = 587976)$				
Step-time	Inflow	Tank	Outflow Promote	Outflw Dropout
Année t_k	vp_{i-1}	E_i	vp_i	vd_i
$t_0 = 2003$	587976	0	0	0
$t_1 = 2004$	587976	587976	442746	46450
$t_2 = 2005$	587976	686756	517127	54254
$t_3 = 2006$	587976	703351	529623	55565
$t_4 = 2007$	587976	706139	531723	55785
$t_1 = 2008$	587976	706607	532075	55822
$t_2 = 2009$	587976	706686	532135	55828
$t_3 = 2010$	587976	706699	532145	55829
$t_4 = 2011$	587976	706701	532146	55829

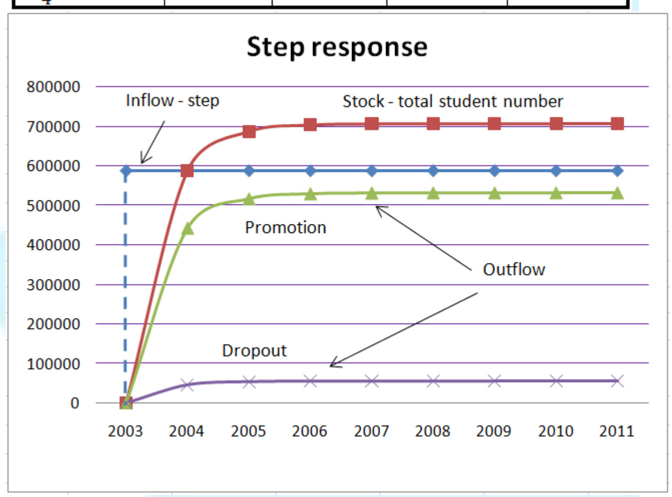

Figure 5: Step response for a grade level

In response to an echelon of amplitude 587976, the content in a grade level, initially null, progresses to 706600.It takes about four years to reach its steadiness. In this state we can see that E_i far exceeds the height of the step vp_{i-1}

3.3 Overtake calculating

Overtake is a difference between E_i and vp_{i-1}. $\Delta = E_i - vp_{i-1}$. On the other hand, inflow equals outflow in equilibrium, so$vp_{i-1} = E_i(p_i + d_i)$.

Knowing that students are classified into only three categories: promoted, repeaters, and excluded or in abandonment situation, we deduce that;

$$p_i + d_i + r_i = 1 \rightarrow (p_i + d_i) \leq 1 \qquad (4)$$

$vp_{i-1} = E_i(p_i + d_i)$. (inflow=outflow) (5)

(4)&(5) → $E_i = vp_{i-1}/p_i + d_i \geq vp_{i-1}$ (6)

$\Delta = E_i - vp_{i-1}$(Overtake) (7)

(4)&(5)→$\Delta = vp_{i-1}\frac{1-(p_i+d_i)}{p_i+d_i}$(8)

The Overtake is null when repetition rate is null.
$\Delta \to 0 \leftrightarrow (p_i + d_i) \to 1 \leftrightarrow r_i \to 0$. Overtake may be reduced by decreasing repetition rate. If minimizing the overtake allows to optimize costs related to additional human and material resources, that does not mean an improvement in the system quality, since the increase of dropout rates also contributes in reducing overtaking while altering both the effectiveness of the system and its efficiency.

4 IDENTIFYING AN EDUCATION CYCLE

For only one grade level it's easy to calculate manually the evolving of a student number taking into consideration the time, but in cascading mode with taking account of various influencing factors; the calculation becomes complicated, and requires advanced simulation tools. An education cycle is a set of cascaded grade level. In the study of a single level, the calculations are basic and allow manual identification of the system. Identifying an education cycle requires lot of calculations, and the task becomes so tedious that it would be more reasonable to use an appropriate simulation tool. In our case we use "iThink©" software dedicated to modeling and simulating dynamic systems.

4.1 Reference data and parameters

This (table 5) includes necessary baseline data to configure dynamo model, according to the characteristics of the Moroccan educational system at reference year [6][7].Modelling of primary cycle Graphic Figure 6 shows

Table 5: Reference data and parameters

	1st	2nd	3th	4th	5th	6th
E_i^{2003}	740582	738031	732026	653584	562677	457738
E_i^{2004}	697434	671562	709028	664718	594004	510204
p_i^{2003}	75,30	80,90	79,70	82,00	82,60	80,71
r_i^{2003}	16,80	15,40	15,30	12,50	10,30	09,90
d_i^{2003}	07,90	03,70	05,00	05,50	07,10	09,40

** Source: Statistical Yearbook 2005 (Morocco)&MEN*

4.2 Modelling of primary cycle

Graphic in (**Figure 6**) shows a dynamo model based on stock flow principle. All parameters, in this model, are related to the Moroccan educational system during year 2003. The ability of emptying the system, and injecting a known student number in the first grade level or in any other levels, allows by simulation to track detailed history of a pupil target cohort. This graphic shows a design of one dynamo model adapted to primary cycle of the Moroccan system where primary cycle consists of six grade levels.

Parameters of model are:

- *TPi: Promotion rate of grade level i*
- *Pi : Promotion of grade level i*
- *TDi: Dropout rate of grade level i*
- *Di : Dropout of grade level i*

4.3 Common model configuration

a) Initials common flow parameters:

The first grade has been identified above, and will be an input stage for the rest of this cycle. Identification task is achieved by study of step and impulse responses of the entire cycle. All values and variables of the common model configuration are given in (**Figure 6**).

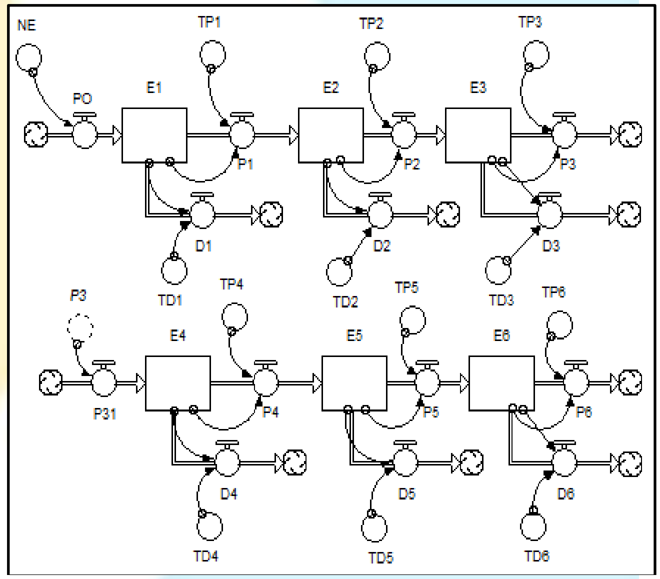

Figure 6: Dynamo model of a primary cycle

Table 6: Common configuration table

Grade levels					
1st	2nd	3th	4th	5th	6th
Variables (promotion rates)					
TP1	TP2	TP3	TP4	TP5	TP6
75,30	80,90	79,70	82,00	82,60	80,71
Variables (Dropout rates)					
TD1	TD2	TD3	TD4	TD5	TD6
07,90	03,70	05,00	05,50	07,10	09,40
Equations for promotion valves					
P1	P2	P3	P4	P5	P6
TP1.E1	TP2.E2	TP3.E3	TP4.E4	TP5.E5	TP6.E6
Equations for dropout valves					
D1	D2	D3	D4	D5	D6
TD1.E1	TD2.E2	TD3.E3	TD4.E4	TD5.E5	TD6.E6

b) General flow equations.

*Ei(t) = Ei(t - dt) + (P_{i-1} - Pi - Di) * dt*
INIT Ei = …
INFLOWS:
*P_{i-1} = E_{i-1}*T P_{i-1}*
OUTFLOWS:
*Pi = Ei*TPi*
*Di = Ei*TDi*

4.4 Impulse response study.

In this study, we first determine flow parameters and flow equations for each level according to the objective. Then, we finally determine initial value for each level. The flow parameters and equations are defined in section 'common configuration'. In this section, the principle of impulse response study is to empty all tanks, disable the new school enrolment: (NE=0) , inject a predefined number of students in the first cycle level (Tank E1) at a specified time (year 2003) as showed in (Figure 7), and start the simulation process.

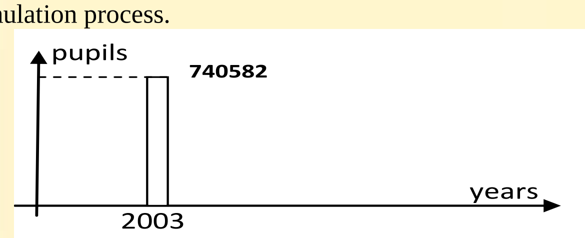

Figure 7: impulse format (at 2003)

a) *Grade levels initialisation.*

At year 2003 taken as a reference year in this study, 740582 was enrolled in first primary grade level of Moroccan system, so level E1 is initialized by this value, and the rest of levels are emptied. The corresponding initialization to the impulse response study is given in table 7, and flow equations that follow are given in the dynamo language.

4.5 Table 7: Grade levels initialization

Initial tanks content					
E1	E2	E3	E4	E5	E6
740582	0	0	0	0	0

b) *Equations of the first level*

*E1(t) = E1(t - dt) + (PO - P1 - D1) * dt*
INIT E1 = 740582
INFLOWS:
*PO = NE*0*
OUTFLOWS:
*P1 = E1*TP1*
*D1 = E1*TD1*

c) *Equations for all other levels*

*Ei(t) = Ei(t - dt) + (P_{i-1} - Pi - Di) * dt*
INIT Ei = 0
INFLOWS:
*P_{i-1} = E_{i-1}*T P_{i-1}*
OUTFLOWS:
*Pi = Ei*TPi*
*Di = Ei*TDi*

d) *Diagram of synthesis equations*

That's a set of equations that allows an overview of the system according to the needs of the study and the simulation objectives. Graphic in (***Figure** 8*), shows the connexions between synthesis variables and corresponding elements of the cycle model. Related to the dynamo model, and diagram of synthesis variables, synthesis equations are given in follow:

absolute__dropout__rate = Total__dropout/Initial_value
Absolute__transition__rate = P6/Initial_value
Initial_value = 740582
Pupil_Headcount = E1+E2+E3+E4+E5+E6
Relative__dropout_rate=Total__dropout/Pupil_Headcount
Relative__transition__rate = Pupil_Headcount/P6
Total__dropout = D1+D2+D3+D4+D5+D6

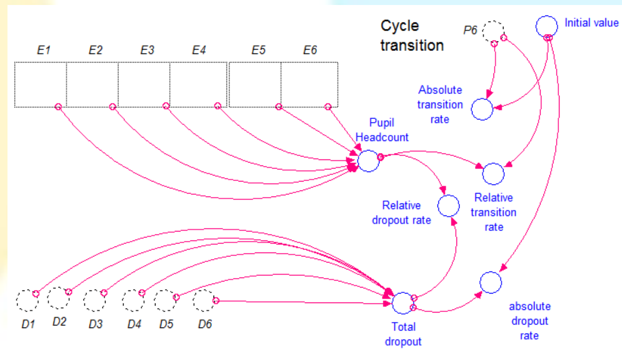

Figure 8: Diagram of synthesis variables

e) *Results of simulation in discrete values*

The simulation in this mode is executed in real. The cycle time given by school year interval relates a real evolving of pupils flow by year and by level.

4.6 Table 8: headcount Evolving.

Years	E1	E2	E3	E4	E5	E6	Total
Initial	740582	0	0	0	0	0	740582
2004	124418	557658	0	0	0	0	682076
2005	20902	179566	451146	0	0	0	651614
2006	3512	43393	214294	359563	0	0	620761
2007	590	9327	67892	215738	294842	0	588388
2008	99	1881	17933	81077	207274	243539	551802
2009	17	364	4265	24427	87832	195294	312199
2010	3	69	947	6453	29077	91864	128412
2011	0	13	200	1562	8286	33103	43164
2012	0	2	41	355	2134	10118	12650
2013	0	0	8	77	511	2763	3360
2014	0	0	2	16	116	695	829
2015	0	0	0	3	25	164	193
2016	0	0	0	1	5	37	43
2017	0	0	0	0	1	8	9
2018	0	0	0	0	0	2	2
2019	0	0	0	0	0	0	0

Table 9: Synthesis parameters

Years	Pupil Headcount	Transition	Total dropout	Absolute transition rate	Relative transition rate	Absolute dropout rate	Relative dropout rate
Initial	740582		58506	0	0	0,08	0,08
2004	682076	0	30462	0	0	0,04	0,04
2005	651614	0	30852	0	0	0,04	0,05
2006	620761	0	32374	0	0	0,04	0,05
2007	588388	0	36586	0	0	0,05	0,06
2008	551802	0	43042	0,27	0,36	0,06	0,08
2009	312199	196560	26165	0,21	0,50	0,04	0,08
2010	128412	157622	11105	0,10	0,58	0,01	0,09
2011	43164	74143	3796	0,04	0,62	0,01	0,09
2012	12650	26717	1124	0,01	0,65	0	0,09
2013	3360	8166	301	0	0,66	0	0,09
2014	829	2230	75	0	0,68	0	0,09
2015	193	561	17	0	0,69	0	0,09
2016	43	133	4	0	0,69	0	0,09
2017	9	30	1	0	0,70	0	0,09
2018	2	6	0	0	0,71	0	0,09
2019	0	1	0	0	0,71	0	0,09
2020	0	0	0	0	0,71	0	0,09

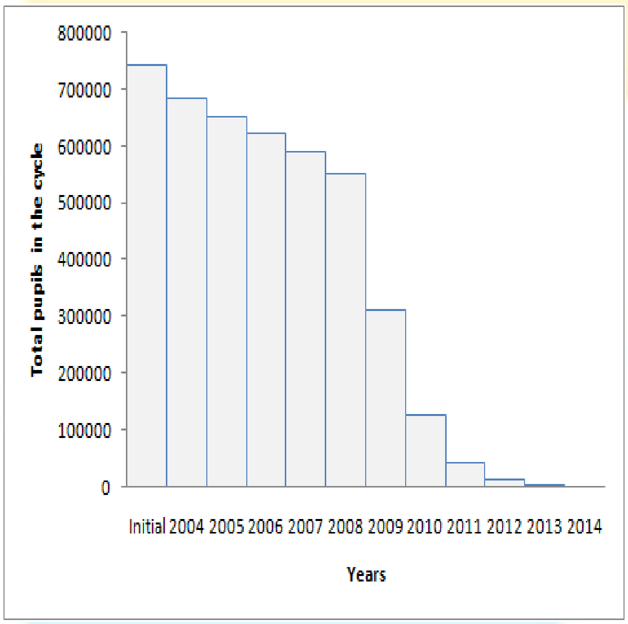

Figure 9: Discrete evolving headcount

f) Results of simulation in integration mode

For an easy analysis and making a possible an academic study, discrete results can be integrated by any interpolations methods. The software used in this work, offer three possibilities to integrate discrete results: Euler method,Runge-Kutta-2 and Runge-Kutta-4 methods. Results summarized in **Table 10**, are obtained through Euler method.

Table 10: headcount Evolving.

Years	E1	E2	E3	E4	E5	E6	Total
Initial	740582	0	0	0	0	0	740582
2004	324441	231166	107256	16855	12285	0	692003
2005	142134	201201	173775	83538	36374	12149	649171
2006	62267	131342	164086	125820	75323	36374	595214
2007	27279	76214	124223	128026	101155	64538	521435
2008	11950	41461	83229	106645	104655	83235	431176
2009	5235	21653	51585	78571	91779	87280	336105
2010	2294	10995	30290	53253	71884	79344	248059
2011	1005	5469	17092	33970	51868	65015	174419
2012	440	2678	9356	20693	35168	49239	117573
2013	193	1295	4999	12156	22709	35058	76409
2014	84	620	2619	6935	14098	23751	48107
2015	37	294	1350	3862	8473	15447	29463
2016	16	139	687	2107	4956	9709	17613
2017	7	65	345	1130	2832	5927	10307
2018	3	30	172	597	1587	3530	5919
2019	1	14	85	311	874	2057	3342
2020	1	7	42	161	474	1176	1859
2021	0	3	20	82	254	661	1020
2022	0	1	10	41	134	366	553
2023	0	1	5	21	70	200	296
2024	0	0	2	10	36	108	157
2025	0	0	1	5	19	58	83
2026	0	0	1	3	10	30	43
2027	0	0	0	1	5	16	22
2028	0	0	0	1	2	8	11
2029	0	0	0	0	1	4	6
2030	0	0	0	0	1	2	3

Table 11: Synthesis parameters

Years	Pupil Headcount	Transition	Total dropout	Absolute transition rate	Relative transition rate	Absolute dropout rate	Relative dropout rate
Initial	740582		58506	0	0	0,08	0,08
2004	696098	0	44679	0	0	0,06	0,06
2005	658049	0	39199	0	0	0,05	0,06
2006	596598	24570	35873	0,03	0,03	0,05	0,06
2007	510583	51340	31868	0,06	0,08	0,04	0,06
2008	413241	66916	26861	0,07	0,13	0,04	0,07
2009	318560	69695	21476	0,08	0,17	0,03	0,07
2010	235685	63468	16390	0,07	0,22	0,02	0,07
2011	168463	52813	12024	0,06	0,25	0,02	0,07
2012	116973	41182	8533	0,04	0,28	0,01	0,07
2013	79249	30572	5889	0,03	0,31	0,01	0,07
2014	52574	21836	3968	0,02	0,33	0,01	0,08
2015	34251	15120	2621	0,02	0,35	0	0,08
2016	21964	10205	1700	0,01	0,37	0	0,08
2017	13891	6741	1087	0,01	0,39	0	0,08
2018	8679	4372	685	0	0,41	0	0,08
2019	5363	2792	427	0	0,42	0	0,08
2020	3282	1758	263	0	0,43	0	0,08
2021	1991	1094	161	0	0,44	0	0,08
2022	1199	674	97	0	0,46	0	0,08
2023	716	411	58	0	0,47	0	0,08
2024	425	248	35	0	0,47	0	0,08
2025	251	149	21	0	0,48	0	0,08
2026	147	89	12	0	0,49	0	0,08
2027	86	53	7	0	0,50	0	0,08
2028	50	31	4	0	0,50	0	0,08
2029	29	18	2	0	0,51	0	0,08
2030	17	11	1	0	0,52	0	0,08

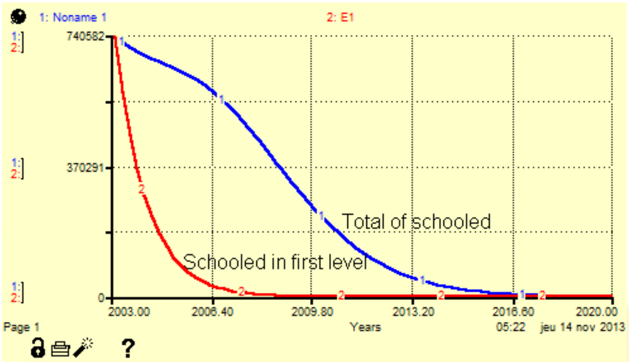

Figure 10: headcount evolving, integrated mode

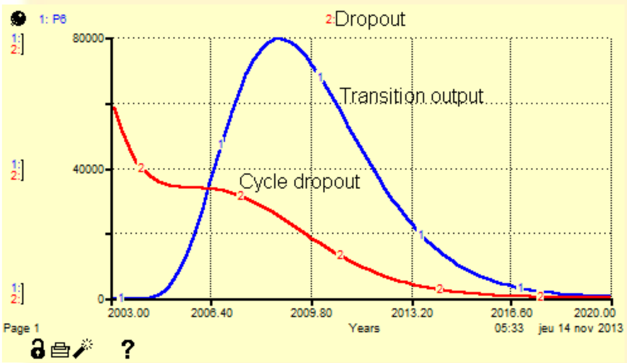

Figure 11: Cycle Output (Transition&Dropout)

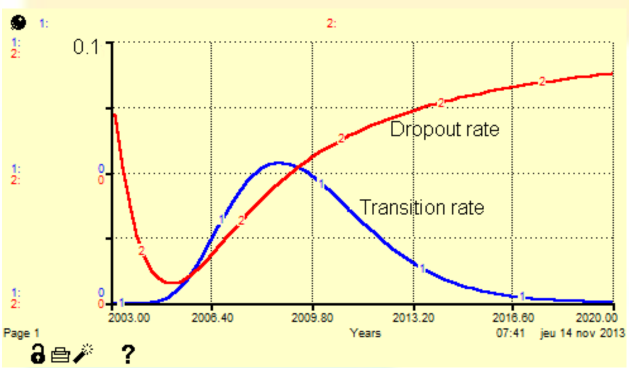

Figure 12: Relatives flow rates, integrated mode

4.7 Interpretation and conclusion

Referring to the dynamic parameters of the system of education identified with year 2003, the number of students enrolled in first grade this year decreases exponentially. We retain of this simulation that in the first year, for example, for only one registration (740,582 students in 2003), some students stays theoretically in this level by repetition for eight years, then there should be material and human resources to ensure education at this grade-level throughout the period, that is to say until 2010. Similarly, in the case of whole cycle, part of the students is retained theoretically by repetition for 16 years, that is to say from 2003 to 2018. In practice, education is compulsory until the age of 15 years past. a student enrolled at the age of 6 years in 2003 has the right to education until 2012. After this date it is automatically excluded which brings the commitment of resources over this period to 10 years, that is to say until 2012. In this year, we notice that it is still in the cycle 12650 students, including 2532 have not yet managed to reach the end of the cycle. If we retain the rate of pupils per teacher of this year taken as a reference year (28.32 students per teacher [8]) the need for teachers for this period is estimated at 26,114 teachers in 2003 to 446 teachers in 2012.

$$Tr_h^{t_k} = E_h^{t_k}/28,36$$

classroom utilization rate in primary school is estimated at 1.5 classes per classroom, with a class per teacher it means that requirement to classroom is 17410 in 2003 to 298 in 2012.

A final point to remember is that the number of students who dropped out of school before 2012 is 274,012 students, and the number of students over the age limit for enrolment after 2012 is 3360 students. The total dropout is 277,372 students that is to say an overall dropout rate of 37.45% in this cohort. We deduce that effects of a fluctuation in the number of students in the first year of the cycle spread over time. Increase, even for a single time the number of new enrolled, leads to commit additional human and material resources during several years (a decade in our example).

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