Exploring the use of System Dynamics in Teaching Civic Education:

An Experiment with High School Students in Colombia

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ABSTRACT

Key words: System dynamics, civic education, K-12 education, experiments.

The need of empowering citizens to become active in civic and political issues is an important element towards development in Colombia. The reality of the country in terms of inequality, armed civil conflict and a negative perception by other countries makes the achievement of this a complex matter. Therein lays the opportunity and the challenge to impact the masses through formal education in civic education. When looking at the actual state of civics instruction, however we see a lack of planning and strategy in the formation of curricula. Despite a variety of different approaches, the condition of the subject does not correspond with the importance of its outcome.

The challenge is then to find a methodology that best articulates the objectives of civics and integrates them with the rest of the social sciences. It is necessary to place the person as a responsible agent knowing the effects of his actions on different spheres. System Dynamics (SD) constitutes a methodology to approach problems and solutions as outcomes of systems. It is centered on the ideas of feedback, systems and dynamics and makes use of computer simulations. SD has been used for 20 years in the field of K-12 education. However, there is relatively little evidence about the effect of SD on changing students' attitudes despite its apparent potential for this.

The present work seeks to explore this possibility of change in the field of civics for Colombia. 120 students from a Colombian high school took part in a collaborative experiment that had the purpose of evaluating the effect of using SD tools in civics and history in comparison to a non-SD teaching method. Pre and posttests were administered to the students in the school environment. The variables measured were comprehension and attitudinal change. We measured how much students improved from pre to posttest after receiving the teaching method.

The experimental results are broadly consistent with the hypothesis that students receiving SD-based instruction would demonstrate more improvement. However, the level of statistical confidence is low. Aspects like a built-in bias of the sample, shortcomings in the measurement instrument, the challenge of a new method based on SD and the short time of exposure to SD explain our outcomes. Future research would be appropriate to test the effects of SD-teaching on civics including a longer treatment period, the use of computer simulation technology, and discussion between students to build their own models based on their consensus. The experiment also created an interest in SD-based civics instruction at the primary-grade level.

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INTRODUCTION

Regarding Colombian public culture, it can be said that "… there are no citizens but inhabitants, users or clients of public services; there are no political parties, but electoral organizations interested in privatizing public founds in their own profit; there is no legitimate authority but a body of employees that look after their own interests as bureaucracy". (Velásquez 1998)

Colombian history is characterized by the existence of a great difficulty to build democratic order. In Pécaut's (1987) words, "order and violence have been the basis for the shared life of Colombians, but violence has not meant the breaking of the institutional order. This circumstance is the one who has shaped a political regime deeply weak but stable, not very representative and closed to the expression of citizens".

As several authorities on the issue have stated before, in order for a democratic order to remain strong and sustain its traditions, the citizenry should be well-informed and civic-minded (USANationalCouncil 1993). Citizens should have trust in government, be politically engaged and connected to their community, and be tolerant (Morgan and Streb 2001). The existence of a culture of the public is necessary to create a collective process. In summary, it is needed for the society to face and solve the big challenges of modernity such as national identity, legitimacy of political system, economic growth, social welfare and sustainable development.(Buendía 1996)

Colombian civic culture then shows a significant weakness. The need then is to counteract this reality with structural measures which go to the core point of the problem. Education provides the conditions for citizens to assume such challenges and give birth to more aware generations, conscious of their role and the importance of it.

What kind of role are we talking about? What is that element that provides awareness and true conscience? We are referring to Citizenship. "Citizenship as use and enrichment of our condition of members of a community […]. Being citizens means to

have demands – based on values, concepts and attitudes – before what is social and communitarian. Citizenship supposes to exercise rights and political responsibilities […]" (Mayordomo 1998).

Preparing individuals to exercise their citizenship includes the gathering of *knowledge* about institutions and procedures: the way the social and political system works; the development of *confidence* to participate in civic life and the development of *skills* to carry that participation out. We are talking about civic education. Education that is successful if it encourages a positive change of students towards participation, a better attitude that implies to transmit information about democracy knowledge, values and ways to participate effectively in the democratic political process.

The need and use of civic education is not a matter of the degree of development of a society. It plays a decisive role in the curricular structure of schools at all their levels (elementary, high school, college, university) in traditional and sustained societies. And in societies developing their democratic order after extreme conditions such as civil war or fragility of government and public structures, the design of the civic education methodology must be enhanced and carefully designed. A careful design and content of our issue of interest is a need reinforced by civics' characteristic of not being inherently passed down from generation to generation – "it requires that each generation of students learn civic facts, explore democratic ideals and connect such concepts to the responsibility of citizenship" (Lubig 2006).

Civics becomes a discipline that nourishes as well as is nourished by other social disciplines as it is at the core of social sciences purpose. As the National Council for the Social Studies of the USA states in its Curriculum Guidelines (1993), "Social studies is the integrated study of the social sciences and humanities to promote civic competence…" Civics learning gets support from philosophy, history, literature, the set of humanities, besides social sciences and law (Mayordomo 1998). It includes a wide range of issues and spheres because in essence it is pursuing the creation of citizenry in all the meaning of the concept.

However, in a study performed by the International Association for the Evaluation of Educational Achievement (IEA) in 2001, in the majority of the participating countries teachers overwhelmingly reported that most emphasis in civic education instruction was placed on factual knowledge transmission. The study shows that over 75 percent of the students in most participating countries were able to answer questions dealing with the fundamental nature of laws and political rights. However, few students in the participating countries could answer more demanding questions on the test that had to do, for example, with deciding between election candidates based on their policy positions, understanding processes of political reform, and grasping the implications of economic and political choices made by policymakers. Many country representatives pointed to substantial gaps between the concepts that schools were trying to foster and what students actually believed.

By contrast to the question about methodology, the percentage of teachers who thought that knowledge transmission ought to be the emphasis was very low, making the differences rather stark between responses on what is and what ought to be. Teachers in most countries tended to choose critical thinking or values education as those objectives they would like to see more emphasized. (Losito and Mintrop 2001) The study showed agreement among specialists that civics-related courses *should be* participative, interactive, related to life in school and community, conducted in a non-authoritarian environment, cognizant of diversity and co-constructed with parents and the community. Many countries, however, saw difficulties in implementing this kind of civic education because it is not a curriculum-bound subject. Reality and vision were thus incongruent. This incongruity motivates the efforts in being more pragmatic when designing civic education courses. (USA Office for Democracy and Governance, 2002).

It is not a straightforward task because there is not one unique path that leads to success in learning and achieving civics attitudes. A review of the literature reveals more than twenty-five pedagogical strategies with varying degrees of appropriateness for teaching civic education in schools. It is unlikely that one pedagogical strategy will prove

to be singularly effective with civics. Experience and research suggest a more probable outcome will be that a combination of strategies will be more effective. (Print & Smith, 2000)

The need for meaningful learning in civics is imperative. By meaningful education we mean the one that fosters the three main dimensions of civics "knowledge, attitudes and skills". It also demands the inclusion of the student in the process and the continuous challenges to student motivation and understanding.

The construction of meaningful knowledge requires tools that actually shape students minds and methods to pursue that goal. With this need in mind, we recognize the potential contribution of system dynamics. System dynamics (SD) is a discipline that uses conceptual tools to deal with complexity and dynamics of systems (Sterman 2000). Developed by Forrester (1958) SD offers a complete methodology to approach the structure of these systems and the behavior they create. SD includes conceptual tools to promote a conceptual framework for building knowledge, and also includes a problem solving methodology to promote willingness and motivation to be engaged in decisions of public interest (Potash 2004). The potential capacity of SD to promote the acquisition and retention of meaningful knowledge would seem to meet the educational need for young people to participate effectively as citizens in their present time and future. SD counts on conceptual tools to organize the way of thinking. Its simulation technique could contribute with a clear image of how elements are connected and how they affect each other. The learning by doing and learner-centered education offers a demanding exercise for students that motivates their thirst for knowledge and comprehension. The strong bounds that link civics with the rest of the social sciences have in SD a tool to make clear those connections and enrich the learning process. SD offers a way of understanding what surrounds us. It offers a type of knowledge that is placed on students' structure of thinking and reading about the world.

With the goal of testing the potential of SD as a teaching tool in civics, an instructional method was designed and used to perform experiments in Colombia in

November of 2006. The subjects were students from the last four years of high school. The experimental design and performance were done in collaboration with my colleague Margarita Cruz and her project in history (Cruz 2007). Both issues, civics and history, were approached with a diffusion model structure. An instructional method without system dynamics content was also developed as a control treatment.

The structure of this paper starts with a presentation of the subject of civics and the traditional ways of teaching it in international and Colombian contexts. Afterwards we explain what SD is and how it is related to the teaching of the social sciences and civics. The experimental design of the current research is part of a third section with all the issues related to the subjects, teaching tools and logistics. A fourth section includes a presentation of the results with their statistical tests and the discussion of them shapes the fifth section where limitations and further research are also presented.

1. CIVICS EDUCATION BACKGROUND

1.1 Foundations of civic education

Civic Education is generally understood to comprise three elements: civic disposition, civic knowledge and civic skills (Branson 1998; Mauhs-Pugh 2003; UNDP 2004; Prior 2006). Civic disposition involves citizens developing confidence to be able to participate in civic life, assuming the roles, rights and responsibilities usually associated with citizenship in democratic systems; being open, tolerant and responsible in exercising their rights and responsibilities. Civic knowledge means that citizens understand their political and civic context, know their social and economic rights as well as their political and civil rights, and understand the roles, rights and responsibilities of citizenship. Civic skills include the ability to explain, analyze, interact, evaluate, defend a position, and monitor processes and outcomes, using knowledge for informed participation in civic and political processes.

Since Plato and Aristotle first discussed the matter, it has been argued that civic education is related to regime type: democracies require democratic citizens, whose specific knowledge, competences, and character would not be as well suited to non-democratic politics. (Galston 2001) At the most basic level, the purpose of civic education in a democracy is to promote thoughtful participation in civic and political life. The promotion of participation has existed since ancient Athens, from the basic recognition of the nature of citizens as *zoon politikon*[1], as Aristotle said. In our own era, political theorists explain the validity and necessity of using civic education to promote the core values and competences essential for a healthy democracy and fully developed citizens. (Beaumont 2002)

What is the rationale behind the capacity of civic education to promote values and competences? The political science literature shows strong premises in that regard. Delli

[1] "Man is by nature a political animal [politikon zoon]," Aristotle, *The Politics,* 1253a1

Carpini and Keeter offer a wealth of evidence that *(1) political knowledge fosters "enlightened self-interest"* – the ability to connect personal/group interest with specific public issues, and to connect those issues with candidates who are more likely to share their views and promote their interests. Political knowledge, then, is a key determinant of instrumental rationality. Utilizing panel surveys from the National Election Studies, Delli Carpini and Keeter find *(2) a strong linear relation between political knowledge and the stability of political attitudes* (Delli-Carpini and Keeter 1996). They also find that more knowledgeable voters display much higher levels of ideological consistency among issues than do the less well-informed. Delli Carpini and Keeter's regression analysis shows a *(3) highly significant independent effect of political knowledge on the probability of voting* (Delli-Carpini and Keeter 1996). The premise of "all other things being equal, the more knowledge citizens have, the more likely they are to participate in public matters" is also studied by Popkin and Dimock (1999) who agreed on this: "The results of our model highlight the strong and independent influence of contextual knowledge on turnout. Controlling for correlated measures of sophistication, knowledge about politics stands out as a consistently strong factor shaping the decision to vote". Popkin and Dimock show that low-information citizens are much more likely to judge officials according to their perception of noncontextual personal character: "Without knowledge of how government works, it is difficult to assess the true priorities of a legislator in the American system … Voters less able to use these political cues will rely on estimates of personal character instead of attitudes about parties and issues…[R]eliance on personal character as proxy of political character is related to uncertainty, and uncertainty is related to a lack of understanding about politics" (Popkin and Dimock 1999). This linkage states that *(4) unless citizens possess a basic level of civic knowledge – especially concerning political institutions and processes – it is difficult for them to understand political events or to integrate new information into an existing framework.* (*5) General civic knowledge can alter our views on specific public issues.* For example, the more knowledge citizens have, the less likely they are to fear new immigrants and their impact on our country (Popkin and Dimock 2000). *(6) The more knowledge citizens have of civic affairs; the less likely they are to experience a generalized mistrust of, or alienation from, public life.* For those who understand politics, debate can be as clear as a tennis match;

for those who don't, it more closely resembles a food fight (Popkin and Dimock 1999). And we could not forget to mention that (*7) civic knowledge promotes support for democratic values*. For example, the more knowledge citizens have of political principles and institutions, the more likely they are to support core democratic principles, starting with tolerance. Nie, Junn, and Stehlik-Barry find direct paths from education to both knowledge of democratic principles and tolerance (Nie, Junn et al. 1996).

Citizenship arises then as the main concept in civic education. Citizenship approached as a quality that involves not only formulating and expressing one's own interests and exercising individual rights, but also recognizing that there are community norms and shared interests that may sometimes contradict and override one's individual preferences. (Beaumont 2002)

Given its rich characterization, the concept of Citizenship has been taught using many different methodologies. There is neither one type of information to be given nor a unique set of skills to be reinforced. There is neither one single source absolutely integral to provide what is needed nor a best way to communicate what stays in teacher's mind and in curriculums. All of this civics characterization lets us see the challenge educators face if proper and effective education is to be given to students.

1.2 Civics for the youth

The main aim when educating on civics is to induce a type of behavior that is consistent with what is taught: committed citizens who are conscious of their role and the impact of their actions. Because of their natural link to practical matters and daily facts, civic discussion and civic issues are present throughout one's lifetime. In different ways and in different moments in life individuals receive preparation to exercise rights and duties. The impact then is also felt in various contexts: self-experience in social and public arena; family, school, media and peer discussion and knowledge transmission, attitudes created by the responsiveness of the system (government and institutions), and others. All these groups are sensitive and need good instruction regarding civic concerns.

Hence civics provides education for adult population as well as for students at elementary, high school and college levels.

Political science and psychological research provide findings on the importance of shaping the youth for their future civic behavior. The logical thought of focusing on the young population as a way of shaping generations with more awareness of the benefits of participation and inclusion, is supported by the findings of social science's researchers.

According to Morgan and Streb (2001), two different theoretical models shed light on such a connection: the *primacy* principle and the *structuring* principle. The *primacy* principle holds that political attitudes are early learned in life and that these attitudes are relatively lasting throughout life. Though research in political science suggests that these early political predispositions are less likely to be fixed, the importance of these early attitudes is generally accepted within education. The *structuring* principle assumes that the orientations that are learned early will persist. These political attitudes will structure the information that we receive later on in life. In other words, new information will be processed and filtered through the political schema that was established as a young adult. Thus these two principles assist in warranting of civic education at early ages.

The attitude-behavior relation is therefore seen at the center of discussion of social psychology for years. Many efforts have been made and leading to the accumulation of a large store of literature on the attitude-behavior relation, which has been incorporated into at least 10 meta-analyses. Glasman and Albarracín (2006) offer a complete analysis on the formation of attitudes to predict behavior where the findings of the previous works are included and their flaws are carefully excluded. Their report states that attitudes seem to influence future behaviors when they are easy to retrieve from memory and are stable over time. In addition, their work shows that expressing attitudes repeatedly and having direct experience with the attitude object influence the attitude—behavior relation by inducing higher attitude accessibility. It also indicates that being motivated to think about an object or issue promotes attitudes associated with one-sided

and behavior-relevant information. Forming attitudes on the basis of behavior-relevant information, receiving or generating one-sided information, and believing that one's attitudes are correct, in turn, strengthen the attitude— behavior relation via greater attitude stability. Thus two attributes of attitudes, accessibility and stability, link it strongly to behavior.

The need then is to guide the efforts on the formation of attitudes with specific characteristics aforementioned and in this way to expect a coherent behavior. The work of Petty, Haugtvedt *et al*. (1995) provides support for the existence of the stability attribute on attitudes as a way to induce subsequent behavior. They found that when talking about changes of attitudes, *persistence* (degree to which an attitude remains unchanged) and *resistance* (attitude's ability to withstand attack) are enhanced in conditions where persuasion is associated with strong message elaboration. Their research suggests that when attitude change was produced under high elaboration conditions, these changes persisted to a greater extent than the same attitude changes produced under low elaboration conditions. The same happened with resistance. This result has occurred when high level of thinking was used because individuals under study liked to think, or attitudes were on important topics, or people directly reported having thought about the issues. That is, when subjects were made more inclined to elaborate messages, either because they were instructed to make self-relevant connections, or because situational factors such as increased personal relevance compelled them to think about the messages, the resulting attitudes were more highly associated with subsequent behavior toward the attitude object.

In the formation of those attitudes the message elaboration regarding civic issues is a key point. In summary, forming civic attitudes with a high probability of predicting future civic behavior in the young learners is the core motivation that comes for placing civic education early in the educational process.

1.3 Methods of teaching civics

A review of the literature on civics methodologies reveals more than twenty-five pedagogical strategies with varying degrees of appropriateness for teaching civic education in schools. An analysis of these strategies suggests a classification into four main categories of pedagogical activity using two intersecting dimensions. (Print and Smith 2000).

One dimension suggests that pedagogies can be classified according to the degree to which students are actively engaged in the learning process. At one end of the continuum lie strategies which are *learner-passive* and cognitively-focused. Here students are directed to learning conceptual tasks through such strategies as traditional expository teaching, document analysis, and using audio-visual curriculum materials. At the other end of this continuum lie the *learner-active*, participatory-focused strategies which seek to engage students in the learning process. Examples include role-play, simulations and cooperative learning strategies.

The second pedagogical dimension represents the teaching-learning context. At one end lies the individual *classroom*, usually a concise physical location with a teacher and a group of students. At the other end of the continuum lies a *whole-school* approach such as whole school projects, school assemblies and elections for students' councils. (Print and Smith 2000)

Table 1 shows evidence concerning strengths and weaknesses of the methods.

	Passive-cognitive learning	**Active-cognitive learning**
CLASS	Appropriate for schools since teachers remain in control and are able to regulate student participation.	Cooperative learning groups, classroom discussion of current events and mini-parliaments. Problem solving, especially exercises using groups. However small group investigations of realistic problems appear to be less than popular with students largely because students are not successfully engaged.
SCHOOL	Important and positive impact on the acquisition of civic values.	Extracurricular activities are far more influential than formal academic classroom activities in nurturing positive values about participation in civic life. School parliaments are rare but offer exciting

		possibilities in enhancing an understanding and practice of active democratic citizen with educational settings. "Democratic schools" are growing slowly but also offer excellent opportunities for students to participate in whole school, active participatory learning experiences.

Table 1. *Weaknesses and strengths of civics approaches* (Print and Smith 2000)

The report *The Civic Mission of Schools* (Carnegie and CIRCLE 2003) summarizes information about the most effective school-based civic education practices and programs from assessments in the USA and in the international sphere. The report chooses six approaches that are listed on the left side of Table 2. The first row has five different areas of civic education. For each approach it is marked with an "x" those areas where it has more benefits. For example Classroom instruction approach benefits the (1) civic and political knowledge of students, their (2) civic and political skills and also their (3) political participation.

		Civic Education Area				
		CIVIC AND POLITICAL KNOWLEDGE	*CIVIC AND POLITICAL SKILLS*	*CIVIC ATTITUDES*	*POLITICAL PARTICIPATION*	*COMMUNITY PARTICIPATION*
Civic Approaches	*Classroom instruction*	X	X		X	
	Discussion of current issues	X	X	X	X	
	Service-learning		X	X		X
	Extracurricular activities		X		X	X
	Student voice in school governance		X	X		
	Simulations	X	X	X		

Table 2. *Civic approaches and their contribution to Civic areas* (Carnegie and CIRCLE 2003)

But what constitutes each of these approaches?

1. Civic knowledge: consists of formal instruction in government, history, law, and democracy. This is a valuable goal in itself and may also contribute to young people's tendency to engage in civic and political activities over the long term.

2. Discussions: are an opportunity to debate current local, national, and international issues and events into the classroom, particularly those that young people view as important to their lives. Students tend to have greater interest in politics, improved critical thinking and communications skills, more civic knowledge, and more interest in discussing public affairs out of school.

3. Service-Learning: is an approach to education that uses community service to advance curricular objectives through written assignments and/or discussions that promote reflection on the service experience and connect it to classroom studies.

4. Extracurricular activities: are activities not related to curriculum or any other academic approach. Students choose them freely according to their interests.

5. School governance: is an opportunity for students to manage their own classrooms and schools.

6. Simulations: consist of using role playing and dramas to simulate democratic processes and procedures: voting, trials, legislative deliberation, and diplomacy.

Given the diverse outcomes of several promising civic approaches but no magic formula, educators, policymakers, and communities have the task of determining priorities. Experience and research suggest that the combination of strategies would yield a more effective outcome. Research will undoubtedly identify some combinations better suited to some students, in some schools, by some teachers. The same combination may not function as effectively in other schooling contexts.(Print and Smith 2000)

What the research suggests, then, is the critical importance of the course design and teaching methods. At one level, this seems obvious, but it has profound programming implications. If civic education programs are well designed and well taught and if they meet frequently, use participatory methods, stress learning by doing, and focus on issues that have direct relevance to participants' daily lives, they can have a significant, positive

impact on democratic participation and attitudes (USA Office for Democracy and Governance 2002).

1.4 IEA Civic Education Study

In 1994 the General Assembly of the International Association for the Evaluation of Educational Achievement (IEA) decided to undertake a study on civic education. The idea was to respond to the expressed need of many countries for empirical data as they began to rethink their civic education programs in the early 1990s. Fifty countries received IEA's invitation to participate in the test and survey reported in the first volume of the report with twenty-eight countries[2] accepting the invitation. Many of those countries were experiencing political, economic and social transitions. Assessing civic education was important not only for these countries, however, but also for societies with long-established democratic traditions. In general, it could be said that changes in the political, social and educational scenes of many countries suggested the timeliness of this new study, particularly in terms of its potential to make a substantial contribution to an understanding of these changes.

The study showed that in civic education, teachers seem to have discretion in emphasizing specific topics, choosing materials and forms of assessments and employing instructional methods. Content that teachers deem important tends to get more coverage. In many countries, teachers express willingness to negotiate curricular topics with students. Teachers use self-produced materials and materials gleaned from the media as well as official sources. They also use a variety of assessments, but essays and oral participation prevail. Civic education classrooms appear to be largely teacher centered, but, according to teachers, this does not preclude discussions of controversial issues. Society's contestations make it difficult, in the eyes of many teachers from many

[2] Australia, Belgium (French), Bulgaria, Chile, Colombia, Cyprus, Czech Republic, Denmark, England, Estonia, Finland, Germany, Greece, Hong Kong (Special Administrative Region of China), Hungary, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, Slovenia, Sweden, Switzerland, United States.

countries, to ascertain what should be learned in civic education, but official curricula and standards can rally consensus.

In most of the countries civic education was reportedly a matter of knowledge transmission whereas critical thinking and political engagement were said to receive less attention. However when asking teachers their opinion about what should be taught, most of them emphasized critical thinking or values education. Reality and vision were thus incongruent. (Losito and Mintrop 2001) Such incongruence could be explained by several situations. On one side, teachers expressed how beholden they feel to national traditions and how it constrains them to teach in a way that makes knowledge transmission central. Thus, despite much teacher discretion and autonomy, policy plays a crucial role in orienting teachers and forging a firm base for the field. On the other side, according to most reports, teachers are insufficiently trained, hence civic education knowledge is more common sense rather than systematic. The subject matter loses out against more career-relevant fields of study, such as math and science. In many countries in the world, civic education is folded into history or language arts instruction and, as a point of reference, ranges well below the status of social studies.(Mintrop 2003)

With such a status we could wonder how the priorities of teachers are established when they choose methodologies and when they are preparing their lectures. It is not clearly seen how they translate it into actions however, even when the meaningfulness and relevance of the field is generally recognized by boards of directors and teachers. Class activities do not necessarily flow from a careful planning process for the progress on civic skills, attitudes and meaningful knowledge. It is possible that teachers focus their time and efforts on setting up and developing other subjects. The EIA study seems to suggest that, in a large number of countries, improvement efforts need to concentrate on instructional essentials: ‘better materials and text books’, ‘additional training in content’ and ‘more time for instruction’.

For those who advocate a different kind of civic education, this gap between reality and vision might be a good leverage point for reform and for the development of

materials and training.(Losito and Mintrop 2001) Using the representative database of the IEA Study, Mintrop (2003) took a look at its findings from the perspective of experts, teachers and students. His comprehension of what the study shows states a decisive situation: "…the field is not where it should be. But the field is in transition".

1.4.1 Colombian case

Colombian civic education is not the exception for such weaknesses. We need also to contextualize the social and political reality of the country. In Colombia the public culture is very fragile. "We have the beauty of a high individual creativity, but we do not have the sense of a collective rationality". The meaning of this fragility is that there are many civil initiatives that do not transcend the sphere of the individual interests. They end in delegating to political actors the decision processes about collective issues. (Velásquez 1998)

The consolidation of a joint consciousness and a sense of the public imply knowledge and require an arduous process of formation for a new citizenry. In Colombia, possibilities for the exercise of citizen participation are ample and occupy the most diverse levels of social life. There are mechanisms for social participation in planning, in the national health system, in residence public services, in the environmental national system, in education and control of public management. Other mechanisms benefit the collective interests of ethnic minorities, women, consumers and the youth; citizens have some controls, alternative mechanisms of conflict resolution and public actions to demand rights, etc. All these mechanisms tend to produce a new type of relationship between society and State that allow the reconstruction of social net from novel perspectives that overcome the logic of armed conflict and the restrictions imposed by social statutes. (Herreño 2002)

The civics study by the EIA shows opposing outcomes for Colombia: it occupied the last place among the 28 participant countries in the knowledge and skills test. Nevertheless, in the attitude questionnaire (survey) Colombia was between the first

places in favorable opinions toward democracy and active participation. The instrument used for the study included two sets of questions: a test and a survey. The test had items assessing *knowledge* of content and items assessing *skills* in interpretation of material with civic or political content. It had keyed correct answers. The survey had three types of items: items assessing how students understand *concepts* such as democracy and citizenship; items assessing students' *attitudes* (for example, feelings of trust in the government) and items assessing students' current and expected participatory *actions* relating to politics. The survey did not have "correct" answers.

Results show there is a devaluation of the role of knowledge. In Colombia the basis for promoting "critical thinking" and "development of values" are ideologies and sentiments and not a rational knowledge. There is a low valuation of social sciences knowledge as well as of its function in democratic education from teachers and Colombian society. This situation is worsened by the absence of general standards for an integrated education of social sciences. This area still does not have curricular guidelines even when education for Values and Democracy has guidelines which account for the positive answer in attitude questions yielded by the study. There is no incorporation of meaningful theoretical networks about concepts such as power, democracy and government. The content exists but is not articulated to history and the rest of the social sciences. (Restrepo, Ayala et al. 2001)

When asking Colombian teachers about what is taught in civics, a high percentage do not know or do not answer (40%). Then 34% of respondents chose "development of values" while 11% of them answered "knowledge about society". 9% registered "student participation in community and political activities" and 7% chose the option "critical thinking".(Restrepo, Ayala et al. 2001) In other words, what is taught the most is what belongs to the shared social knowledge, while what is taught the least belongs to a more complex knowledge which is also less common. It requires more cognitive effort, more theoretical elaboration and more reasoning for the acquisition of conceptual networks that allow one to deduce or induce.

1.5 Civics in need for significant knowledge

Getting to know the importance of the field and the way civics instruction impacts social and political order formulates several questions. All of those questions belong to the sphere of civic education for the youth coming from their schools. If the final goal is to promote conscious activism in the adults and we know already about the linkage 'youth attitudes – adult behavior', are schools working towards the formation of strong attitudes? That question could go even further, are schools working on the elaboration of strong civic messages to create those necessary attitudes? Are students motivated to use high level of thinking on civic issues? Are they guided to make self-relevant connections on how civic matters work and how they influence the society they live in? Are they invited to discover the relevance civic should have on their development as members of a community?

The meaningful knowledge the youth need to form these attitudes is a must in their education. Civic courses demand a careful design that meets such requirements. Outcomes from the EIA study for Colombia show that the favorable attitudes towards democracy are not determined on a rational basis. It makes them likely to be weak, with low *persistence* and *resistance*, and susceptible to change. Colombian civic education is not forming long lasting attitudes. In the conceptual formation it is not enough with simulation of government or democracy. If these experiences are not integrated to cognitive competences in social sciences and with crucial concepts of them such as democracy, state, nation, constitution, rights and liberties, they take the risk of resting on intentions or in attitudes that not always are translated into actions.(Restrepo, Ayala et al. 2001)

The area of civic education is in need of constant and effective contributions. As wide as the area is, the efforts should pursue the aim of integrating the elements recognized as shaping a complete education in civics (disposition, knowledge and skills) to guarantee an appropriate education for citizens. It is important to learn the history, the facts, the procedures and other issues that already exist but it is equally important to understand the propensity and ability to think and this should be reinforced. The

challenge is learning to learn; not only to see the path but also to look for it, identify it and accept or reject.

The description of Colombian civic culture presents an ambiguous country. Colombians face the difficulties of their present knowing the high impact of their past. Even with all the inequalities that exist there is more and more access to education and progress. Citizens become more informed as well as public institutions read these changes and generate accessible mechanisms for participation. However that is not the reality for many areas of the country. Colombia has wide regions of rural territory. Governments throughout the years have not been able to assist every community. The absence of the state is a given as well as the precarious conditions these communities have lived in. They have been exposed to the lacking of opportunities and the possibility to build their lives as they would like them to be.

Colombian government has a tremendous responsibility in ensuring basic living conditions for all Colombians. This is its major task and what states are supposed to pursue. However, the civic and political contribution citizens could provide plays a significant role in the stability of democracy and control of government. As inhabitants from cities gain more access (in opposition to rural reality), knowledge and skills, they have a say in public issues. It is not only a way of enhancing citizens' power but also a way of articulating the country networks by controlling authorities performance and proposing useful alternatives. It is also a way of injecting positivism to communities that are surrounded by hopelessness and feelings of being unable to interfere and impact their present and future. As those who have the access make use of their participatory mechanisms they could work for those who do not have it. In the end it is translated into benefits for the whole population. Hence social studies education, especially civics education, is a focal point for national transition, as social studies integrate disciplines that have at their center social development of human beings. A portion of the population has the accessibility and possibility of being civically empowered. The benefits of civic education are recognized and promoted all around the world and the situation of the country demands for citizens' participation. The educational institutions at all its levels

have a responsibility on building significant civic knowledge to promote responsible civic behavior.

2. SYSTEM DYNAMICS

2.1 Foundations of System Dynamics

System dynamics (SD) is a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. SD is also a rigorous modeling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations. (Sterman 2000)

Forrester (1994) stated that the objectives of an SD education might be grouped under three headings:

1. *Developing personal skills:* A SD education should sharpen clarity of thought and provide a basis for improved communication. It should build courage for holding unconventional opinions. It should instill a personal philosophy that is consistent with the complex world, in which we live.

2. *Shaping an outlook and personality to fit the 21st century:* A systems education should give students confidence that they can shape their own futures. A systems education should help mold a personality that looks for causes and solutions. Working with systems should reveal the strengths and weaknesses of mental models and show how mental models and computer models can reinforce one another.

3. *Understanding the nature of systems in which we work and live:* We live in a network of complex systems. Yet few people realize the extent to which those systems control human actions. In fact, few people realize the extent to which complex systems actively mislead people into making counterproductive decisions.

Richmond (1991) defined SD as containing a series of activities which range from the conceptual to the technical:

- Systems perspective
- Feedback diagram

- Stock and Flow diagram
- Equational simulation

The adoption of a systems perspective or viewpoint requires you to stand back far enough — in both space and time — to be able to see the underlying web of *ongoing, reciprocal relationships* which are cycling to produce the patterns of behavior that a system is exhibiting. You're employing a systems perspective when you can see the forest (of relationships) *and* the trees.

In this exploration of the world as a set of systems, the central concepts SD uses to account for that systemic structure appear: stocks, flows and feedback relationships. Stocks are accumulations of material or information. Their contribution to dynamics is critical as they characterize the states of the system and provide the basis for actions and provide systems with inertia and memory. They are the source of delays and create disequilibrium dynamics. The flows are the rates at which these states change. Feedback refers to the process of X affecting Y, followed by an effect of Y on X through a circular chain of causes and effects with some delays along the chain. In other words, feedback is a process whereby an initial cause ripples through a chain of causation ultimately to reaffect itself (Martin 1997). The feedback loop constitutes the fundamental unit of analysis in contrast to studying the individual relationships between elements.

A simple graphical representation of these three basic elements is shown in Figure1:

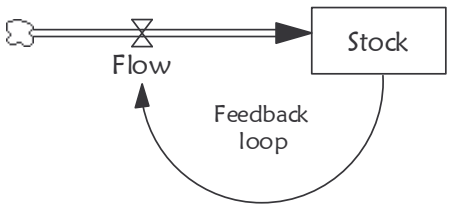

Figure 1. *Generic Stock and Flow structure*

In Figure 1 stocks are represented by rectangles, flows as pipes (thick arrows into and out of a stock) and connectors (thin arrows) that move information from one element of the system/map to another. In this simple case the connector allows us to see the feedback loop.

If we look at an example, the concepts of stocks, flows and feedbacks might look clearer: consider the case of a population, which increases through time. Thinking in terms of accumulation and changes over time leads us to identify that the number of inhabitants within a population are accumulated, and that such accumulation occurs according to the number of births over time. Thus, the population can be considered a stock of people and the births over time can be considered as the rate that increases the stock of population. The inflow of births add to the population stock. Figure 2 shows the S&F representation of this example.

Figure 2. *Births-Population relationship represented by an S&F structure.*

However, the larger the population, the more births occur. Thus, the relationship between this inflow and this stock is mutual. While the population is increased by births over time, the births are increased by the population. In the S&F nomenclature, such relationship is represented by a thin arrow going from the stock to the inflow. And the entire mutual relationship between population and births is represented by the *feedback loop*.

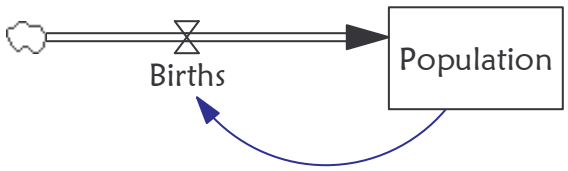

Figure 3. *Births-Population-Births relationship using an S&F structure.*

Besides the existence of S&F diagrams, there is another tool to represent the structure of systems. While S&F maps depict stock accumulations, flows and feeback, the Causal Loop Diagram (CLD) is a simplified representation of the S&F structure, and it is useful for focusing attention on the feedback structure. The CLD consists of variables connected by *causal links*, shown by arrows, denoting the causal influences among the variables. Each causal link is assigned a polarity, either positive (+) or negative (–) to indicate how the dependent variable changes when the independent variable changes (Sterman 2000).

The feedback relationship between Births and Population is shown in CLD format in Figure 4.

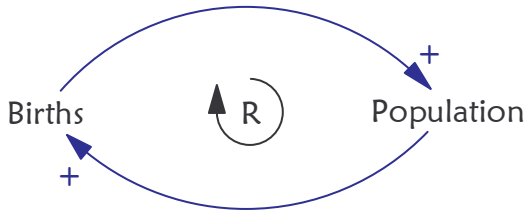

Figure 4. *Births-Population-Births relationship using a CLD.*

Feedback loops can be reinforcing (positive) or balancing (negative). When an increase in the initial element causes an impact in the same direction in the other element, then this relationship is a positive one. In the example of population, the relationship between births and population is positive in both ways: an increase in births causes population to grow, and an increase in population makes births augment.

However, when an increase in the initial element causes an impact in the opposite direction on the other element, then the relationship is considered as a negative one. For example, an increase in deaths causes population to decrease. (Sterman 2000) Figures 5 and 6 depict such relationship using a S&F diagram and a CLD respectively.

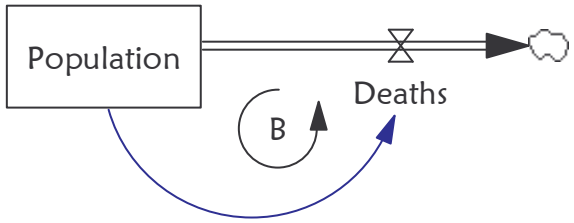

Figure 5.*Population-Deaths-Population relationship represented by an S&F structure.*

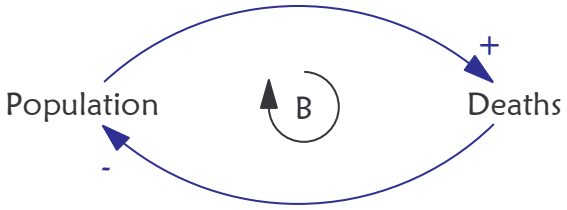

Figure 6.*Population-Deaths-Population relationship represented by a CLD.*

The combined diagram would look like this:

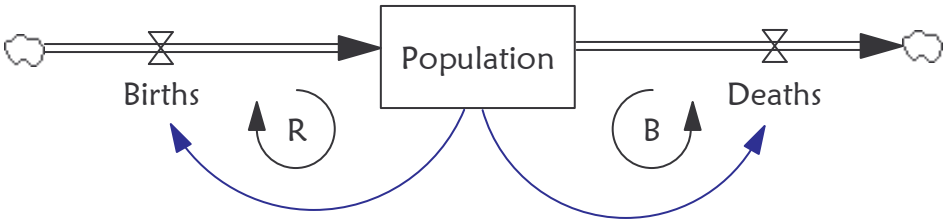

Figure 7. *Births-Population-Deaths structure using S&F.*

The CLD would be like this:

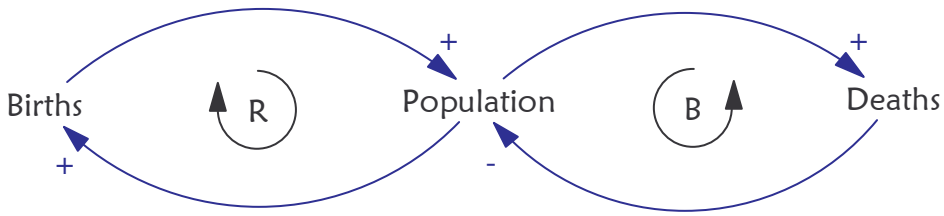

Figure 8. *Births-Population-Deaths structure using CLD.*

The positive relationship between the births and the number of inhabitants in the population is shown through the arrow with the positive polarity. The same happens with the relationships population to deaths and population to births. The only negative polarity that goes from deaths to population has a negative sign. The type of feedback loop is labeled with the respective letter to reinforcing (R) or balancing (B).

2.2 Does SD have a place in the teaching of social sciences? Does SD have a place in teaching civics?

SD is first, a set of conceptual tools particularly suited to understanding issues arising in complex systems, and second, a problem solving methodology that emphasizes actively managing change. These two aspects are related to a twofold challenge of social sciences: the need to provide students with a useful conceptual framework for building knowledge, and the willingness or motivation to be engaged in making decisions "for the public good" (Potash 2004).

However these two aspects are not the only ones that connect social sciences with system dynamics. Social studies have a special characterization of human-centered and multidisciplinary. "Social studies is the integrated study of the social sciences and humanities to promote civic competence…The primary purpose of social studies is to help young people develop the ability to make informed and reasoned decisions for the public good as citizens of a culturally diverse, democratic society in an interdependent world."(USANationalCouncil 1993) The multidisciplinary character is evidenced by the usual confining of social sciences to geography, economics, history, and civics/government. The rationale for these choices clearly reflects the recognition that these four disciplines provide a conceptual foundation for examining the overarching or most significant themes that underlie the purpose of social studies (Potash 2004). Each of these disciplines effectively constitutes a key building block in constructing a larger reality. And implicit in these understandings is the belief that the relationships/interactions between these variables account for many of the important dynamics of change that underlie the human progression from past to present and, even more importantly, inform the course of possible futures. Knowledge in any single

discipline may be useful for exposing some facet of the problem, but will unlikely, in isolation, be sufficient for effectively managing the problem (Potash 2004). The usefulness, then, of a systemic approach for integrating the areas of social studies can be seen. SD originates from the powerful idea of the existence of complex-dynamics relationships involving feedback that connects multiple systems and generate oft-times complex, non-linear behaviors. Social sciences, then, is human-centered and multidisciplinary, and Potash (2004) reminds us that in SD, “the message is in the feedback and the feedback is always interdisciplinary.”

Consider the example of the dynamics in a classroom. The teacher and students establish channels to communicate. They send messages to each other. The one who provides knowledge and is attentive to the learning process, and the one who learns and responds to the teacher's motivation. Thus each one of them is an element of a system where feedback occurs. The two of them are engaged in constant change, always responding to the dynamics of the communication. These responses represent feedback and have different dimensions in the context of a classroom: students can show their willingness, anxiety, fear, confidence, and stress through different biological indications such as sweating. The teacher should be able to read and understand them to give an appropriate response as well. The teacher could also contextualize a response in the historical record of how the students’ normally respond. From that perspective teacher interpretation could also be changed. In summary, the message that comes from the feedback is different and requires an interdisciplinary interpretation. If we think about the linkages between students we could see a broader system. There are no static laws but, instead, dynamic complexity. There are different types of learners and there is always change to meet the needs of those different learners. Conventional teaching methods rely on a model of teachers inputting information into the classroom. However other methodologies focus on the learning that occurs among students and the perspective of teachers as learners. SD therefore may be an effective approach to meet the complexities that occur in the learning of social systems.

In his penetrating discussion of the learning process, Bruner (1963, p.24) states, "the most basic thing that can be said about human memory… is that unless detail is

placed into a structured pattern, it is rapidly forgotten". For most purposes in social sciences, such a structure is inadequate if it is only a static framework. The structure should show the dynamic significance of the relationships, how they influence one another, and how past behavior and future outcomes arise from decision-making policies and their interconnections. SD can provide that dynamic framework to give meaning to detailed facts. Such a dynamic framework can provide a common foundation beneath mathematics, physical science, social studies, biology, history, and even literature.(Forrester 1992)

We could think of another simple example to show how a dynamic structure provides foundation to learning in different areas. We will use the S&F structure of one stock with one inflow and one outflow showed previously to depict the relationships between Births – Population – Deaths (without the feedback loops to simplify):

Figure 9. *Births-Population-Deaths structure without feedback using S&F.*

There is a mathematic rationale behind stocks and flows relationships. Stocks can be represented as integral equations:

$$Stock = \int_{t_0}^{t} (Inflow - Outflow)dt + Stock_0$$

While flows can be represented using differential equations:

$$d(Stock)/dt = Inflow - Outflow$$

This structure then is useful to approach calculus lessons:

Figure 10. *Inflow-Stock-Outflow structure using S&F.*

The usefulness of the structure influences natural sciences as well. We could think of the concentration of CO2 as determined by the inflow of emissions and the outflow of absorption.

Figure 11. CO2 *Emissions-Concentration-Absorption structure using S&F.*

We can see that the same structure is useful to approach issues in different areas; in this case social sciences, calculus and ecology.

Civics is one of the four main disciplines of social sciences. Meeting the conceptual need in understanding civic issues and the need for motivation and willingness to exercise citizenship can, perhaps, be facilitated by SD's combination of conceptual tools and problem solving methodology.

Civic *disposition*, civic *knowledge* and civic *skills* are those spheres to work on when educating for citizenship and each of them is related to the other as the exercise of citizenship is one single corpus of activities. This means that elements and interconnections exist at the interior of civics and we can approach them with a systems perspective. My hypothesis is that understanding how the system works promotes not only the willingness to participate in it and be more active but also the development of positive attitudes towards that system.

As we explained in section 1, formation of strong attitudes has a positive effect on behavior related to those attitudes. If we concentrate on the inherent characteristic of SD

as placing knowledge in a structure of reasoning and requiring high level of thinking we could see the potential SD has to generate deep understanding and then contribute significantly to the strength of attitudes. Using SD to lecture about civic issues would require students to get actively involved in the process of understanding and therefore have a higher probability of keeping on their minds that learning. With the knowledge learned from such experience, we think they would form positive and long lasting attitudes towards the civics' issues studied.

The potential of SD to make knowledge meaningful meets the need of meaningful civic knowledge for the young people to participate effectively as adult citizens. People with more education are more likely to vote, to follow and understand current events, and to join voluntary associations than those in the same generation with less education. Although this may be in part because educated people tend to have more money, social status, and discretionary time, it is also likely that education itself facilitates participation because being an engaged and effective citizen today requires more than just reading, writing, and mathematics skills. It also requires the ability to understand complex issues (which sometimes have scientific or economic dimensions), knowledge of computers and the Internet; and the ability to talk with people from different backgrounds (Carnegie and CIRCLE 2003)

2.3 SD experience in teaching in K-12 level

Several high schools, curriculum-development projects, and colleges are using a SD core to build study units in mathematics, science and social studies. Roberts (1978) first demonstrated SD as an organizing framework for education. Her work with students at the fifth and sixth grade levels suggested an advantage in reversing the traditional educational sequence. That traditional sequence consists of five steps:

1) learning facts,
2) comprehending meaning,
3) applying facts to generalizations,
4) analyzing to break material into constituent parts,
5) synthesizing to assemble parts into a whole.

Roberts contends that most students never reach that fifth step of synthesis. But, synthesis—putting it all together—should be placed at the beginning of the educational sequence. Roberts' arguments hold that by the time students are in school they already possess a wealth of observations about family, interpersonal relations, community, and school. They are ready for a framework into which the facts can be fitted. Unless that framework exists, teaching still more facts loses significance.

The efforts of educators to introduce SD analytical tools into the classroom, as early as kindergarten, began only in the late 1980s. Gordon Brown was the pioneer in "feedback control systems" at MIT and commandeered Jay Forrester as he entered to MIT in the early 1940s. After he retired in 1973 he started to think and discuss about problems in local schools. Brown decided that systems thinking and modeling methods could "help kids improve their interest in learning and not become dropouts," and he set out to champion a systems approach to education (Hight 1995). A pivot point in his lobbying activities came in the spring of 1988, when he took a Macintosh computer loaded with STELLA dynamic modeling software to a meeting with the superintendent of the local Catalina Foothills school district. The superintendent was intrigued by this quick demonstration and suggested that Brown meet Frank Draper, a biology teacher at Orange Grove Middle School in Tucson, Arizona. At that encounter, Brown suggested that Draper borrow the STELLA software for the weekend. It was an inspired gesture. "This is what I have always been looking for," Draper reported to Brown. Brown and Draper were able to line up enough computers and software for Draper's classes when school began. Brown described his role as the "citizen champion" engaged in drawing all participants in the school system together in their search for a new kind of education. Positive effects were seen in a greater student involvement which produced a more rapid pace of completion of the subject content. (Forrester 1994)

In humanities, a dynamic framework can even organize the study of literature. Classes taught by Pamela Hopkins are from an underprivileged section of the city and many had been labeled as slow learners. Simulation opened the door to a new way of capturing student interest and involvement. In a seminar for teachers taught by Barry Richmond and Steve Peterson of High Performance Systems, she participated in

developing a model of psychological dynamics in Shakespeare's *Hamlet*. (Forrester 1994)

Introducing SD concepts is very natural in mathematics. The understanding of functions from their characteristic behavior-over-time/rate-of-change patterns would provide a natural link to other disciplines and real applications and can be implemented as early as Algebra I (Fisher and Zaraza 1997). This work in the field of mathematics has been done by Diana Fisher.

The existence of associations such as The Creative Learning Exchange and Water Foundations has been crucial for the penetration of SD in K-12 education. The possibility of sharing experiences and material through their resources management, conferences, newsletter, list serves is invaluable.

In social sciences SD has also done its part. In teaching economics the development of simulators and lessons in this matter are a proof of it. Hirsch (2003) created a simulator that teaches students economics in terms of a familiar economic institution, the retail store. The simulator casts the economics of a store within a System Dynamics framework. This enables students to understand the importance of feedback relationships in determining economic performance and viability of a business. An SD framework also enables them to understand the relationships among concepts such as demand, price, service quality, and the range of merchandise offered and available and how they change over time in relation to each other. In Carlisle, Massachusetts teachers have developed several basic economics lessons using system dynamics for students in fourth to eighth grade. One obvious and useful system dynamics application to the study of basic economics is the modeling of bank balances. Carlisle students do bank balance lessons in fourth, sixth and eighth grade. With increasing complexity and independence they build basic system dynamics models to understand how money accumulates with simple and compounding interest. They learn about deposits and withdrawals as flows into and out of their stocks of money. They are introduced to the ordinary business of living. (Lyneis, Quaden et al. 2003). Perhaps the first to experimentally assess the impact of using SD as an instructional tool in economics, Wheat (2007) tested the effectiveness

of feedback loop diagramming when teaching economic dynamics. Students using the "feedback method" outperformed those using traditional graphical methods. While most of the students in his experiments were college undergraduates, many were secondary students. Even students without higher order math training were able to learn about dynamic behavior in a market economy.

Jeff Potash and John Heinbokel have worked extensively in the social sciences with SD. Their research and contributions started in the history field. They have produced a large body of curricular and training materials which vary in topic, time commitment, and skill level or tools required. This experience and information have led to the creation of a conceptual framework to address social science issues. Examples of their work are case studies to examine the dynamics and impacts of diseases such as smallpox. They compare the history of plagues with STELLA models of what happened during the plagues from a biological perspective. They cover the Athenian Plague (Circa 429 b.c.) through AIDS today.

The work of Cruz (2007) followed Wheat's experimental interest on assessing the impact of using SD. She focused on the field of history with Colombian students. Her findings support the positive effect of SD in enhancing students' understanding of history, specifically revolutions.

Multiple applications of SD and efforts in improving students' difficulties using SD are goals for a growing number of teachers in the K-12 level. However, with the exception of Wheat and Cruz, there has been no experimental investigation of the effectiveness of SD-based teaching methods in the social sciences.

2.4 Model for Promoting Active Citizenship

The SD approach civics instruction in this paper made use of a reinforcing loop with the variables Experience, Civic Efficacy and Confidence. This virtuous circle gets support from the political science literature. As Putnam (1997) stated in his study of civic traditions in Italy, 'stocks of social capital, such as trust, norms, and networks, tend to be

self-reinforcing and cumulative' leading to a virtuous circle of civic engagement, interpersonal trust and confidence in government. By contrast, 'distrust, shirking, exploitation, isolation, disorder, and stagnation intensify one another in a suffocating miasma of vicious circles'.

The acquisition of Experience in participation builds Civic Efficacy. Citizens develop skills as well as get knowledge and tools as a result of their participation. These assets they get are the ones that make it worthy for them to be willing to exercise social and political responsibilities. This capacity to actually make a difference in civic issues is named Civic Efficacy. The more they feel they are effective, the more confident they are: they are more confident they can pursue and achieve their civic purposes. In this way, the more Civic Efficacy, the more Confidence. Confidence, in turn, promotes the acquisition of more Experience.

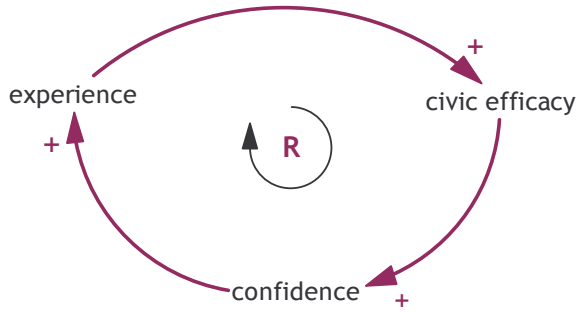

Figure 12. *Reinforcing loop of Experience–Civic Efficacy–Confidence–Experience*

The link between Confidence and Experience exists because the Confidence developed by Activists generates the need of sharing with others their own beliefs. Therefore there is a process of diffusion in which people pass from being Non-activists to Activists. The diffusion process of people passing from one stock to another has been captured in an SD structure called The Diffusion Model (reference such as Sterman 2000). This diffusion model was initially developed to model infectious diseases. As its behavior could represent bacteria spreading through an animal population, a virus spreading through a computer network, a rumor spreading through a school, the adoption of a fad in a country, or any other type of contagious agent, all of them could be

represented by that diffusion structure. Social studies concepts could include the spread of ideas, social movements, or revolutions. (Quaden, Ticotsky et al. 2004)

In our model to promote active citizenship we have two stocks: Non-Activists and Activists. The total population of the community or region represented in the model is divided in two categories: those who are Non-Activists, and those who are Activists. As people are converted to being active they move from the Non-Activist category to the Activist category. The model invokes a number of simplifying assumptions. First, births, deaths and migrations are ignored. Second, once people are Activists, they remain Activists indefinitely. People in the community interact at a certain rate (*Frequency of Contacts*). Some of these encounters are with Activists. Not every encounter with an Activist results in an Activation. The *Probability to generate an Activation* is the probability that a person becomes Activist after contact with an Activist person. In the model, once an Activist arrives in the community, every Non-activist person eventually becomes activist. The higher the Frequency of Contacts or the greater the Probability to generate an activation, the faster the activation progresses[3]. The next S&F diagram represents the structure:

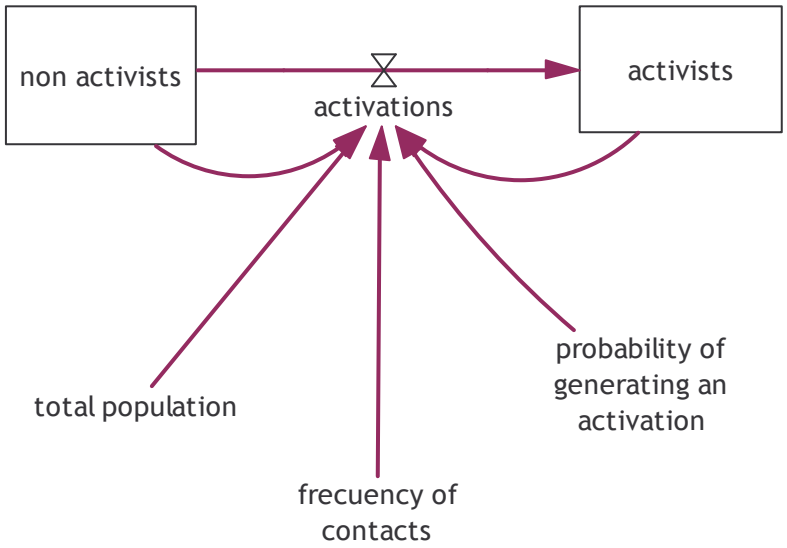

Figure 13. *Diffusion model for the Activation process (adapted from Sterman, 2000, p. 301).*

[3] Further information about the Diffusion model and its variations can be found in Sterman (2000), Business Dynamics: Systems Thinking and Modeling for a Complex World.

Thus we place the Diffusion structure in the link between Confidence and Experience. The more Confidence promotes a higher sense of Persuasiveness. The more Persuasive a person is the more is able to generate an activation. The more Confidence also has a positive effect on the Frequency of Contacts. Activists would be more willing to share their experience and message with more people. After a process of diffusion, those who were activated increase the stock of common Experience that all Activists fill. With this linkage we close the feedback loop Experience – Civic Efficacy – Confidence. Figure 10 shows the whole model.

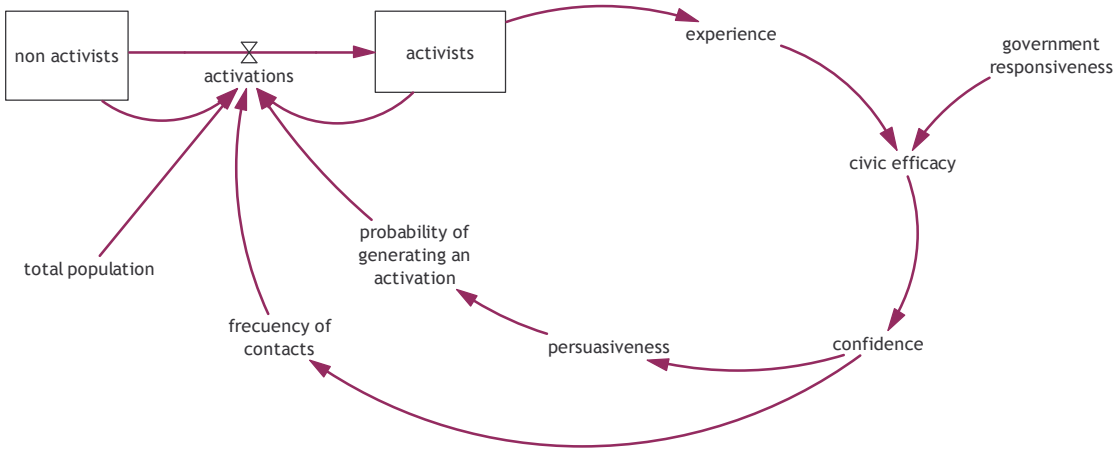

Figure 14. *Complete diagram of the virtuous circle Experience–Civic Efficacy–Confidence–Experience.*

There is one last element we included in the process: *government responsiveness*. It is an external variable to this specific process and has an effect on civic efficacy. The more the public institutions create rooms for citizens' expression and are more opened to be influenced by civic input, the more civic efficacy people would have.

3. THE EXPERIMENT

The civics experiment reported here was part of a larger experiment in social science instruction using SD. The other part was developed by Margarita Cruz (2007) in the field of history.

3.1 Experimental Design

120 students took part in the experiment. There were two different teaching methods characterized by either the presence or the absence of SD language and tools. 60 students were assigned to the non-SD teaching method and the other 60 took the SD teaching method. Each of those two big groups was also divided in two to apply a different field sequence: 30 students took civics lesson first and on the other day they took history; and the other 30 students changed the order of the sequence: they took the Cruz (2007) history lesson first and secondly civics. This design resulted in one group of 60 students receiving no SD instruction, 30 students receiving two lecture periods of SD instruction and another group of 30 receiving three lecture periods of SD instruction. The content of the lessons was given through slide show presentations. The use of slides was encouraged as a way of minimizing the effect on instruction resulting from teacher variation in delivery and explanation of instructional content.

The first day of instruction for the groups who took SD teaching method was a Preliminary session consisting of a 2.5 hours during which the main concepts of SD were introduced and explained. The method chosen for this session was an oral presentation by a trained person[4]. The training for this person was done during a first stage (pilot

[4] The person in charge of conducting the experiments in November was a Management Engineering student. She had taken a course in SD so she was familiar with the language, the diagrams and the tools. There was a Power Point software presentation done in advance for her to lecture the preliminary session to the students. Each slide had also a script where she found what she should say to the students. All the recommendations and experience got in the pilot experiment were transmitted to her in a very detailed way. During the sessions with the students our facilitator had the company of a teacher from the school to guarantee the control of students' discipline.

experiment) of the experimental process that was performed during the summer of 2006 in Colombia. The pilot experiment consisted in a series of experiments in different schools as a first approach to experimental research, students' handling, and schools' directives treatment. Results from that experience allowed the improvement of the content presented to the students in the slide show presentations, the measurement tool, the control of the sessions, the logistics of the different sessions (time and material), and the management of information.

This preliminary session also included a practical section for the students to feel closer to SD field and concepts they were seeing for the first time. They played a game called the *Infection Game* which teaches the basic diffusion model, which is a major part of the model used in the experiment.

The table below shows the procedure for each group: how many days each of them dedicated to the learning of civics and at which point they were evaluated.

	SD0		**SD1**	**SD2**
	Pretest for all groups: Comprehension and Attitude			
Day 1	Non-SD slide show presentation *civics*.	Non-SD slide show presentation *history*.	Preliminary session.	Preliminary session.
	Posttest: Comprehension and Attitude			
Day 2		Non-SD slide show presentation *civics*.	SD slide show presentation *civics*.	SD slide show presentation *history*.
		Posttest: Comprehension and Attitude	*Posttest: Comprehension and Attitude*	
Day 3				Slide show presentation *civics*.
				Posttest: Comprehension and Attitude

Table 3. *Treatment for each group*.

3.1.1 The Infection Game[5]

This game simulates the spread of an epidemic. The interaction that drives the spread of an epidemic was represented by the shaking of hands. One student was anonymously assigned as the initial infected subject at the beginning of the game, while the rest were non-infected subjects. As they shook hands in pairs, the repeated shaking process caused more and more students to become infected. The infected state remained for the whole game. The model captures the most fundamental features of infectious diseases: the disease spreads through contact between non-infected and infected individuals. Figure 10 depicts the model.

Students in the classroom interact (shake hands) at a certain rate. At the beginning of the game there is just one person in our stock of Infected. The rest of the students belong to Non-infected. We count the interactions of Infected students and name them "contacts per infected" per day. Those contacts potentially infect someone else. As not all of them produce an infection we need to consider the "probability to infect". In the game that probability depended on a coin toss during each "daily" round of the game. All these elements together including the total number of students (total population) shape a simple way to represent the dynamics of infectious diseases.

[5] Bibliographic references to know about the epidemic game and how to administer it:
http://sysdyn.clexchange.org/sdep/Roadmaps/RM5/D-4243-3.pdf
http://clexchange.org/ftp/documents/x-curricular/CC2005-01ShapeInfectionGame.pdf

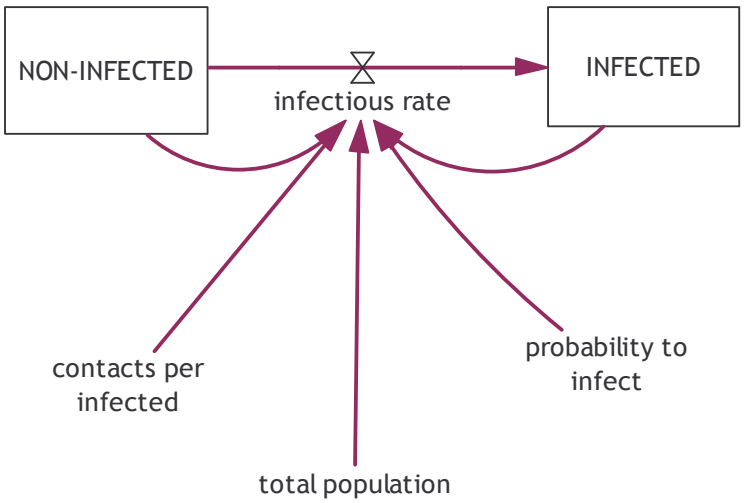

Figure 15. *Diffusion model diagram (adapted from Sterman, 2000, p. 301).*

There was a debriefing session after the game in which all the abstract definitions explained in the first part of the preliminary session became more concrete for the students after having the experience of a diffusion process first hand. They were asked about their impression of the diffusion process, how they though the quantity of infected people grew, and how many infections occurred on each opportunity of shaking hands. Afterwards the real behavior of these variables was shown and students got a detailed explanation of the process of diffusion they experienced when playing the game. They participated in the discussion and gave some other examples they could see in daily life.

On a different day after the preliminary session one group students (*SD1*) took the civics SD-based slide show presentation. The other group (*SD2*) took the history lesson and, on another day, the civics lesson. SD1 and SD2 answered the posttest just after finishing the civics slide show presentation. The other students (*SD0*) who took the non-SD teaching method did not have any preliminary session about SD. Half received the civics lesson on the first day, and the remainder received it the second day.

3.1.2 The instructional content

The central idea of the instruction was to emphasize that the individual process of accumulating experience, building confidence and communicate personal conviction, does not have power by itself. There is no incentive for one person to change unless an important fraction of the population has the same beliefs and decides to be active.

The purpose was to let the student think about his role as part of a society which builds on a –basic– premise of engagement and participation. The idea of the contribution of a single person to his society is easily weaken if the characteristic of a collective effort is not brought to the analysis. What is the usefulness of a person's contribution if he is alone?

Both –SD and Non-SD– instructional material covered the same issue of activating people in a community. Non-SD content used just words and description of the same process that the SD method covered using S&F diagrams and CLD. Each element of the Model to Promote Active Citizenship was included in the presentation for the SD groups, one at a time, with a complete definition of its meaning and effect on the process.

Many of the elements (if not all) of the process were variables that students should know already. Such learning comes from their classes or even from the general shared knowledge in communities, families, schools, and media. These variables were activists, experience in civic participation, civic efficacy, confidence in civic effectiveness, capacity of persuasion.

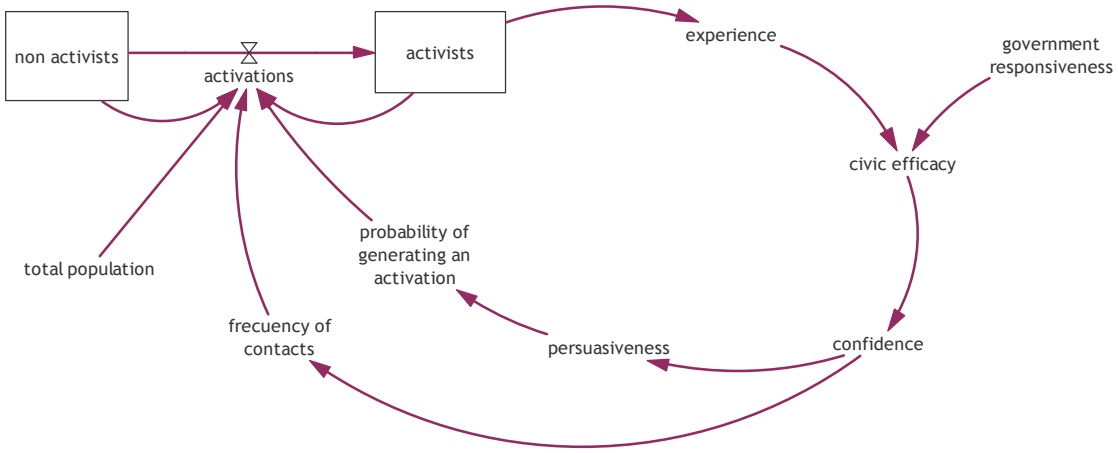

Figure 16. *Model to promote active citizenship*

The Non-SD content did not use any of the SD terms (stock, flow, feedback, reinforcing, balancing) or diagrams. It was a story using a simple and clear vocabulary.

3.1.3 Slide show presentations

The content of the slide show presentations[6] differed according to the teaching method. SD instructional method for groups SD1 and SD2 was longer (45 slides) as it included stock and flow diagrams and explanations. The slide show presentation (30 slides) for the control group (SD0) described the same process but only through words and no use of concepts such as accumulations or feedback in the context of the dynamics of the system described. The flow of the SD slide show started with mentioning the diffusion model explained in the previous day with the Infection game and from there we continued describing how that same model could be applied to the Model to Promote Active Citizenship. After showing the diffusion structure for Non-Activists – Activists, we continued with the rest of the structure emphasizing the existence of the reinforcing loop that acts as the propelling mechanism for the diffusion. Students could go through the loops seeing the details as well as the big picture (the trees and forest).

Students studied 30 slides which, on average, took 30 minutes. Student s in the SD1 and SD2 groups received the preliminary session (2 hours and a half) followed by a

[6] The total set of slides is part of the Appendix.

presentation with 45 slides. SD students finished, on average, in 1 hour. The additional slides plus the greater complexity of SD as a new discipline for them required more attention and time. The students in SD1 and SD2 not only had to understand the process of activation but also recall how to read and interpret the diagrams and. It was a more complex task.

3.2 Test Instrument

The measurement tool was made up by two different tests, one measuring comprehension and the other measuring attitudes. All the students had to answer Pre and Posttest which had exactly the same questions.

3.2.1 Comprehension Test

For the Comprehension test the students (from SD0, SD1 and SD2) had to read a story: the City of Naga. The story was taken and adapted from the website of YouthXchange, a project that makes use of accessible information, concrete examples and everyday language to assist youth groups, NGOs, and teachers in raising student awareness on sustainable consumption and empowering youth to put the theory on sustainable lifestyle choices into practice. YouthXchange has been developed in partnership with UNESCO, UNEP, MÉTA and Consumers International. (YouthXchange 2005) The story tells the case of Naga, a city in the Philippines, which is a good example of inclusion of citizens in the development of their city. They used a program called Government-I to empower citizens and commit them actively in the elaboration of government policies, as well as in the implementation and evaluation of programs. It uses different media such as “The Guide of the citizenship”, Internet, printed and broadcasting tools as well as emails. We adapted the story to a process of diffusion where citizens start to share the benefits of the initiative with others. The power communication yields positive results for the development of the city and welfare of its inhabitants.

The table below shows the questions and answers to the Comprehension test. Cells highlighted in gray are the correct answer per question. The case study of the City of Naga is in the Appendix 6. Questions were created to match the content developed in the story with the aims of the lesson. Originally the story does not come with those questions.

No.	QUESTION	A	B	C	D
1	Which relationship below is most like the relationship between non-activists and activists?	Men and Women	Business owners and Factory workers	Homes without a computer and homes with computer	Using a credit card to make purchases and using cash to make purchase
2	The relationship you find between activists and activations is similar to the one that you find between:	People who believe in God and conversions	Orders of pizza and Deliveries of pizza	People who got a disease and Vaccinations	Number of chickens in a farm and Meals that include chicken in a farm.
3	Which relationship below is an example of the relationship between the number of activists and their frequency of participation?	the number of students in the school and the frequency that each student attends school.	the number of homes with a computer and the frequency of computer commercials on television.	the number of mothers in a nation and the frequency that mothers give their children a goodnight kiss.	the number of high-achieving students in a class and the frequency that each student joins in class discussion.
4	Which relationship below is an example of the relationship between the number of activists and their possibility of getting someone to become active?	supporters of a soccer team and probability of winning a match	housewives who use a special brand of washing powder and probability of convincing other housewives of using it	candidates to be major of the city and probability of getting elected	students who got graduated from college and probability of getting a good job
5	As the number of citizens involved in civic affairs increases, that	encourages others to get involved because everyone wants to be involved.	discourages others from getting involved because they know that activism is not effective.	encourages others to get involved if they can see that activism is effective.	has no effect on others.
6	As activists use media frequently enough:	they gain confidence because there are few others who do it and for them it is important to be original	they get discouraged because it is difficult to use the media tools	they gain confidence because they see that using the media has a positive impact on their environment	they gain confidence because there are many others who are doing the same
7	As activists gain confidence on the importance of participating:	their arguments to convince others are stronger because they really believe in what they are doing and it is reliable	their arguments to convince others are not appreciated because the rest of the people see them as servile people	their arguments to convince others are stronger because it is well seen to use such modern tools	their arguments to convince others do not change

Table 4. *Comprehension Test questions and answers*.

After reading the City of Naga story students had to answer seven questions. Questions can be grouped in three groups which account for different kind of tasks. Questions 1 and 2 are very conceptual: relationships between concepts that can represent accumulations (stocks) and others that can be seen as rates (flows). Even when a correct answer could be chosen intuitively, it was expected a higher accuracy from students who took SD-teaching method as they were explained about stock and flows and examples in real life.

In the model for Promoting Active Citizenship there are two elements (Frequency of Contacts and Probability of generating an activation) that are the central. They place the diffusion structure in the *virtuous circle* of experience, civic efficacy and confidence. These elements are part of two reinforcing loops that propel the objective of increasing the number of activists through the *virtuous circle*. Those are the aims of questions 3 and 4. It was expected that with a clearer picture of the loops and the variables involved in it, more students who took SD teaching method could answer correctly in comparison to non-SD students.

Questions 5, 6 and 7 questions ask for the effect that occurs after a described situation. It also asks for the reason that explains a described effect. These questions are "As the number of citizens involved in civic affairs increases…", "As activists use media frequently enough…", "As activists gain confidence on the importance of participating". SD-teaching method possibly could have placed a clearer picture of the model and its loops. The clearer picture means more understanding which could cause a better performance when answering the questions.

There is also a chance of being accurate when answering these questions due to "common sense" logic when reading, interpreting and guessing the answer. However, answers to the whole test are expected to have better accuracy for SD students as SD concepts and way of presenting the content has the probability of simplifying the process and the comprehension of it.

3.2.2 Attitude Test

The second test was an Attitude Test. It contains eleven statements requiring student agreement or disagreement taken from different scales related to attitudes about civic competencies. As the table below shows, each question belongs to a different scale and some of them are related to civic knowledge.

	STATEMENT	SOURCE SCALE
1	I feel disconnected from the world around me.	**Social Connectedness Scale** (Lee & Robbins, 1995) The scale assesses the degree to which youth feel connected to others in their social environment. *Ages*: 14-18 (Grades 8-12).
2	I think I can make the difference in my society.	**Civic Attitudes Scale** (Mabry, 1998)**.** This scale measures civic attitudes related to participation in community service. The items assess the extent to which youth are willing to assume responsibility to help others and solve societal problems. *Ages*: 12- 17years of age (grade 6-12).
3	I can strongly say to a partner that what he/she is doing is not good for the society.	**Social Self-Efficacy Scale** (Muris, 2001) This subscale measures youths' self-assessments of their ability to negotiate social situations and produce successful social interactions. *Ages*: This scale is recommended for youth ages 14-18 (Grades 8-12).
4	Being citizens is only related to civil actions such as voting, participating in political groups and parties, being politician, etc.	Civic knowledge
5	My family and I have a role to play as citizens in our society.	Modified from **Political Efficacy Scale** The *Hahn Political Efficacy scale* contained items developed at the University of Michigan's Survey Research Center and others developed by Hahn (1997).
6	Children and young people must wait until they grow up to behave as citizens.	Modified from **Political Efficacy Scale** The *Hahn Political Efficacy scale* contained items developed at the University of Michigan's Survey Research Center and others developed by Hahn. (1997)

7	Following the coexistence and participation rules can influence the society in which I live.	Civic knowledge
8	Only if enough people play their role of citizens will society be influenced.	Modified from **Political Efficacy Scale** (also comprehension of the process) The *Hahn Political Efficacy scale* contained items developed at the University of Michigan's Survey Research Center and others developed by Hahn. (1997)
9	I enjoy conversations and discussions about participation and citizen engagement.	Modified from **Political interest Scale** The *Hahn Political Interest scale* used items developed by Ehman and Gillespie (1975). It also contained items developed at the University of Michigan's Survey Research Center which had been used extensively since the 1960s (1997)
10	I am interested in knowing my rights and responsibilities as a citizen.	Modified from **Political interest Scale** The *Hahn Political Interest scale* used items developed by Ehman and Gillespie (1975). It also contained items developed at the University of Michigan's Survey Research Center which had been used extensively since the 1960s (1997)
11	I think I would enjoy being part of campaigns that promote civil engagement and participation.	Modified from **Political interest Scale** The *Hahn Political Interest scale* used items developed by Ehman and Gillespie (1975). It also contained items developed at the University of Michigan's Survey Research Center which had been used extensively since the 1960s (1997)

Table 5. *Statements in the Attitudes Test.*

A Likert scale was used to evaluate student responses to the attitude statements, with five response options ranging from “Strongly disagree” to “Strongly agree” for each assertion. The five response options were assigned arbitrary values from -2 to 2.

Strongly disagree	-2
Disagree somewhat	-1
Neither agrees nor disagrees	0
Agree somewhat	1
Strongly agree	2

Table 6. *Values assigned to each response item.*

The 11 statements measured different civics attitudes. Some of them were measuring the same attitude and so we grouped those items to create scales. We formed two scales: civic interest and sense of civic efficacy.

CIVIC INTEREST	SENSE OF CIVIC EFFICACY
I enjoy conversations and discussions about participation and citizen engagement	I can strongly say to a partner that what he/she is doing is not good for the society
I am interested in knowing my rights and responsibilities as a citizen	I think I can make the difference in my society
I think I would enjoy being part of campaigns that promote civil engagement and participation	

Table 7. *Civic Attitude scales.*

Students' scores could vary from -6 to 6 for the Interest scale, and from -4 to 4 for the Sense of Efficacy scale. Subjects took both tests (Comprehension and Attitude) before and after the experiment, which produced scores for Pretest and Posttest.

3.3 Measures of performance

We compared the scores from Pre and Posttest to indicate improvement due to instruction. We measured two different types of improvement: the Breadth of the improvement and the Depth of the improvement.

Breadth of Improvement

The Breadth of the improvement (BI) was measured using an indicator that calculates the proportion of students per group who had better performance in posttest than in pretest. Breadth of improvement was measured in both tests (Comprehension, CBI, and Attitude, ABI). The better performance in Attitude means that students indicate a higher agreement with the attitude measured (Sense of Civic Efficacy and Civic Interest). A higher Likert score shows a higher level of agreement. The BI for attitude then shows the percentage of students who indicated a higher sense of agreement with the attitude measured after the treatment.

$$BI = \frac{Number\_of\_Students\_who\_\mathrm{Im}\,proved}{Total\_number\_of\_students}$$

Equation 1. *Breadth of Improvement*

Depth of Improvement

For the Depth of the improvement (DI) we used two different indicators depending on the test. For the Comprehension Depth of Improvement (CDI) we made use of the proposal of Marx and Cummings (2007). We used an indicator that involves the ratio of the gain to the maximum possible gain or the loss to the maximum possible loss. Marx and Cummings called it the Normalized Change.

The normalized change is calculated as follows: if a student's performance improves from the pre-test to post-test, we use *Equation2 (a)*; if a student's performance worsens, we use an analogous expression, which is the ratio of the actual loss to the maximum possible loss (*Equation2 (d)*). They found that even in effective teaching scenarios, some students do not improve their scores. Occasionally an overall class average on a diagnostic tool will decrease. To account properly for this decrease, it is necessary to have a way to accurately quantify these changes. If the student's pre-test score is equal to the post-test score, *CDI=0* except when a student earns a perfect score on the pre-test and post-test. In the latter case we argue that this student's scores should be removed from the data sets because the student's performance is beyond the scope of the measurement instrument. Likewise, a student who scores 0 on both the pre-test and post-test should also be removed from the data sets. (Marx and Cummings 2007)

$$CDI = \begin{cases} \dfrac{Post - \Pr e}{100 - \Pr e} & post \rangle pre \quad (a) \\ Drop & post = pre = 100 \; or \; 0 \quad (b) \\ 0 & post = pre \quad (c) \\ \dfrac{Post - \Pr e}{\Pr e} & post \langle pre \quad (d) \end{cases}$$

Equation 2. *Comprehension Depth of Improvement (CDI)*

For measuring the Attitude Depth of Improvement (ADI) we used the absolute difference between pre and posttest. Attitude test did not have correct answers but a level

of agreement with each assertion. Scores ranged from negative to positive values as numbers from -2 to 2 were assigned to the answers. We summed up the scores per question to have a score for the entire test per student. The assignment of values from -2 to 2 was very illustrative of positive and negative attitudes when looking at students' answers but at the same time the existence of positive and negative values made confusing the use of Equation 3. For that reason we use Equation 3. When a student evidences a better performance in attitude when calculating his ADI then Equation 3 produces a positive result. It means the student had a higher agreement with the statements included in the scale used.

$$ADI = Posttest\_score - \Pr etest\_score$$

Equation 3. *Attitude Depth of Improvement (DIA)*

Using each of the measurement techniques for improvement, analysis required making comparisons between groups who took the SD approach (SD1 and SD2) and did not (SD0), in order to look for significant differences.

3.4 Hypothesis

The purpose of the experiment was to test for significant performance differences between students in groups SD0, SD1 and SD2.

3.4.1 Comprehension Hypothesis

CBI Null hypothesis: There is no significant difference in the CBI test of SD0, SD1 and SD2.

$H_{0,\,CBI}$: $CBI_{SD\,0} = CBI_{SD1} = CBI_{SD2}$

CDI Null hypothesis: There is no significant difference in the CDI of SD0, SD1 and SD2.

$H_{0, CDI}$: $CDI_{SD0} = CDI_{SD1} = CDI_{SD2}$

3.4.2 Attitude Hypothesis

ABI Null hypothesis: There is no significant difference in the ABI test of SD0, SD1 and SD2.

$H_{0, ABI}$: $ABI_{SD\,0} = ABI_{SD1} = ABI_{SD2}$

ADI Null hypothesis: There is no significant difference in the ADI of SD0, SD1 and SD2.

$H_{0, ADI}$: $ADI_{SD0} = ADI_{SD1} = ADI_{SD2}$

3.5 Context of the Experiment: The Setting and the Students

The experiments were conducted during the first two weeks of November of 2006. These are the last two weeks of the academic year in Colombia. Students were distracted by the upcoming exams and the requirement of fulfilling their academic commitments. Teachers were also preparing and grading final exams as well as making reports. The board of directors and administrative staff were working hard to complete their mandatory tasks and all their regular work before leaving for the holidays. Everyone at the school then was focused on important and urgent activities. Due to this situation, participation in the experiment was not a high priority for the students, and facilitation of the experiment itself was not a high priority of teachers and administrators.

Students from 8^{th}, 9^{th}, 10^{th} and 11^{th} grade were the subjects. Their ages ranged from 14 to 18. Most of the subjects were male students. In both SD groups the 100% of the students were male while in the Control group this percentage was of 87%.

Group	Grade	# of students	Weighted average of grade level
SD 0	*8th*	14	10.28
	10th	1	
	11th	45	
SD 1	*9th*	5	9.83
	10th	25	
SD 2	*9th*	8	9.73
	10th	22	

Table 8. *Number of students and levels per group.*

As a way of getting to know more about the comparability of the groups, it was possible to have access to their marks on the subject of social sciences which is the one directly linked to the content of the civics instruction. Besides including the common sub-areas of history, geography, Colombian institutions and civics, the subject at this school also includes road safety rules and ethics. In Colombia high school students' marks are qualitative. There is no numeric scale but a scale like this:

- E (Excellent) as the best
- S (Outstanding – "Sobresaliente" in Spanish)
- A (Acceptable)
- I (Insufficient) as the lowest grade

None of the students had an E as the definite mark for the year on the social sciences subject. Students' marks were distributed like follows:

Group	Mark	# of students	%
SD 0	*S*	57	95%
	A	3	5%
	I	0	0%
SD 1	*S*	23	77%
	A	6	20%

	I	1	3%
SD 2	*S*	19	63%
	A	10	33%
	I	1	3%

Table 9. *Distribution of students' marks per group.*

The SD0 group had the highest average grades.

4. RESULTS

4.1 Comprehension Test

Looking at the scores for each group in pre and posttest of Comprehension test we could have an idea of the available room to improve that students had. Students could get scores from 0 to 7 on this test. Table 10 displays the average scores.

	Pre	Post	% Improvement
SD0	3.32	3.55	7%
SD1	4.73	4.87	3%
SD2	3.50	3.73	7%

Table 10. *Average scores for Pre and Posttests in Comprehension test.*

From Table 10 we can initially say that in average the three groups show improvement on Comprehension. Looking at improvement in percentage terms, SD0 and SD2 were about the same (7% improvement in average scores), while SD1 was about half of the amount (3% improvement). The pretest benchmarks for SD1 and SD2 were higher. However, instructional effects on performance are likely to be nonlinear; improvement becomes more difficult for higher levels of initial performance. Thus, when the starting points are different, percentage improvement comparisons may be misleading.

4.1.1 Breadth of Improvement

Table 11 shows that SD0 group had more students who improved than its SD1 and SD2 counterparts. 42% of the subjects from SD0 performed better in the posttest that in the pretest. And a higher percentage of students from SD2 (37%) improved in comparison with SD1 (30%). None of three comparisons displayed in Table 11 were statistically significant, however.

The statistical procedure used to look for statistically significant differences in the performance of the groups regarding the Comprehension test was a t-test for independent samples. The significant value was 0.05.

	SD 0	SD 1	P value
BIC	42%	30%	0.287

	SD 0	SD 2	P value
BIC	42%	37%	0.365

	SD 1	SD 2	P value
BIC	30%	37%	0.591

Table 11. *BIC scores and P-values.*

4.1.2 Depth of Improvement

The DIC measure of performance shows how much of the initial gap students had they were actually able to close. This measure meets the need of overcoming the possible misleading of mere percentage improvement. It considers the initial benchmark of each student and calculates the measurement. It yields different scores as each percentage of improvement would have a different weight depending on the benchmark.

The SD groups both of them – SD1 and SD2 – had better results than the SD0 group. SD0 students closed their gap an average of 1.8%, compared to 9.6% and 7.5% for SD1 and SD2, respectively. Table 12 displays these results. Table 13 shows the depth of improvement comparison between SD0 and the pooled results of the two SD groups (SD1+SD2). The results displayed in both tables are consistent with our hypothesis that students receiving the SD-based instruction would demonstrate more improvement. Nevertheless, as the p-values indicate in both tables, the confidence level associated with these results is not as high as the standard we established for rejecting the null hypothesis.

	SD 0	SD 1	P value
DIC	1.8%	9.6%	0.365

	SD 0	SD 2	P value
DIC	1.8%	7.5%	0.501

	SD 1	SD 2	P value
DIC	9.6%	7.5%	0.831

Table 12. *DIC scores and p-values.*

	SD 0	SD1 + SD2	P value
DIC	1.8%	8.6%	0.330

Table 13. *DIC scores when pooling SD1 and SD2*

4.2 Attitude Test

Table 14 shows the average scores for each group in pre and posttest of Attitude test. Students could get scores from -6 to 6 in the Civic Interest test and from -4 to 4 in the Sense of Civic Efficacy one. Table 14 shows the average scores per group per test and the average improvement in percentage.

	Civic Interest			Sense of Civic Efficacy		
	Pre	**Post**	**% Improvement**	**Pre**	**Post**	**% Improvement**
SD0	1.63	1.95	19.6%	1.95	1.88	-3.60%
SD1	1.40	2.26	61.40%	1.63	1.86	14.10%
SD2	1.80	2.27	26.10%	1.10	1.70	54.50%

Table 14. *Average scores for Pre and Posttests in Attitude test.*

In average the three groups improved in the Civic Interest test. SD1 had a greater improvement (61.40%) in comparison to the other groups and also had the lowest benchmark. SD0 was the group with the lowest percentage improvement. In the Sense of Efficacy test, SD1 and SD2 showed improvement while SD0 decreased. SD0 is the group with the highest benchmark while SD2 has the lowest benchmark and the highest percentage improvement.

4.2.1 Breadth of Improvement

To determine breadth of improvement in attitude (BIA), we calculated the percentage of students whose post-test scores exceeded their pre-test scores. Separate calculations were done for each group (SD0, SD1, and SD2) for the two attitudes measured: Interest and Sense of Efficacy.

4.2.1.1 Civic Interest

Results from Civic Interest questions show better results for SD groups. Forty-seven (47) percent of the students in the SD1 and SD0 groups displayed a higher level of interest after the instruction, compared to thirty-eight (38) percent in group SD0. Nevertheless, the differences were not statistically significant.

	SD 0	SD 1	P value
BIA	38.3%	46.7%	0.454

	SD 0	SD 2	P value
BIA	38.3%	46.7%	0.454

	SD 1	SD 2	P value
BIA	46.7%	46.7%	1

Table 15. *BIA scores for Interest and p-values.*

	SD 0	SD1 + SD2	P value
BIA	38.33%	46.67%	0.360

Table 16. *BIA scores for Interest when pooling SD1 and SD2*

4.2.1.2 Sense of Civic Efficacy

With respect to the for Sense of Civic Efficacy questions, a higher percentage of students from SD1 and SD2 had more positive answers on the posttest than SD0 students. Still, however, the level of statistical significance was below the point at which we reject the null hypothesis.

	SD 0	SD 1	P value
BI	35%	40%	0.647

	SD 0	SD 2	P value
BI	35%	50%	0.175

	SD 1	SD 2	P value
BI	40%	50%	0.445

Table 17. *BIA scores for Sense of Efficacy and p – values.*

	SD 0	SD1 + SD2	P value
BIA	35%	45%	0.267

Table 18. *BIA scores for Sense Efficacy when pooling SD1 and SD2*

4.2.2 Depth of Improvement

For each student we calculated the DIA by subtracting the Pretest score from the Posttest. The value for all the students is averaged by group and that is what we compare.

The type of data we gathered with the Likert type items that formed the scales was ordinal data that have an inherent order or sequence. However, we cannot assume that the respondent means that the difference between agreeing and strongly agreeing is the same as between agreeing and being undecided. This fact plus the data not being continuous makes the inferential techniques to be non-parametric.

The non-parametric technique used was the Kruskal Wallis test, which evaluates the impact of the days of exposure to SD teaching method on the Depth of Improvement (DIA) of the Interest and Efficacy tests. The test makes one single comparison at a time for SD0, SD1 and SD2 looking for any effect. If we get a statistical confirmation of some effect we would perform another test to look for the direction of it.

	SD0	SD1	SD2	P - value
DIA Interest	0.317	0.867	0.467	0.610

	SD0	SD1	SD2	P - value
DIA Sense of Efficacy	-0.067	0.233	0.600	0.436

Table 19. *DIA scores and p-values.*

The values we are comparing are the means of the differences post – pretest scores for the three groups. For Interest as well as for Sense of Efficacy, SD students showed greater positive change. SD0 students improved 0.317 for Interest while SD1 and SD2 had 0.867 and 0.467 respectively. For Sense of Efficacy SD0 students' scores deteriorated and SD1 and SD2 improved (0.233 and 0.600 respectively).

The Kruskal Wallis test produces p-values higher than the significant value. The results of the attitude tests show results in the direction of the hypothesis but the statistical test does not confirm it.

Table 20 shows the SD vs. non-SD comparison after pooling the results of SD1 and SD2, and the interpretation is the same as in Table 19. The results show deeper attitude improvement among the SD students, but the desired level of statistical confidence is not achieved (based on a Mann-Whitney test for two samples).

	SD0	SD1 + SD2	P - value
DIA Interest	0.317	0.667	0.452

	SD0	SD1 + SD2	P - value
DIA Sense of Efficacy	-0.067	0.417	0.222

Table 20. *DIA scores and p-values when pooling SD1 and SD2.*

With table 21 we summarize our results. For each test we indicate the consistency (or not) with hypothesis as well as the statistically significance (at the 0.05 level of confidence).

Test	Are results consistent with hypothesis	Are results statistically significant at the 0.05 level of confidence?
Comprenhension		
Breadth of Improvement	No	No
Depth of Improvement	Yes	No
Attitude		
Breadth of Improvement	Yes	No
Depth of Improvement	Yes	No

Table 21. *Summary of Results*

The experimental results are broadly consistent with the hypothesis that students receiving SD-based instruction would demonstrate more improvement. The exception is the BIC test. Just as clearly, however, is the low level of statistical confidence that can be attached to these results. Next section focuses on explaining the causes for these outcomes.

5. DISCUSSION

Since the results were not statistically significant, we now examine factors that may have influenced those results and ask whether such factors may have biased the outcome in either direction. We can approach our results from two different and complementary perspectives: external and internal factors. By external factors we mean those related to the subjects, their circumstances, and their characteristics. A very important aspect when designing an experiment is to keep it clear from biases that would make harder to measure our effects of interest. For that reason, we need to make sure of the randomization when getting the subjects and forming the samples. When we do that we want to guarantee that if we apply the same treatment we would get the same results as the subjects would have the same skills. Internal factors are related to the tools we used, the way of measuring performance and our expectations regarding our variables.

5.1 External factors

There is some evidence (Table 9, on page 58) to suggest that group SD0 was academically stronger than the other groups. The distribution of students' marks make us wonder if the differences between students' performances in the area of social sciences is significant enough to consider it as determinant of the outcome in the activity students realized in the civics experiment. We did statistical tests to test whether there was any correlation between the variables Group (SD0, SD1 and SD2) and Marks (S, A, I).

A chi-square test indicates a statistically significant difference in marks between the SD0 group and both SD1 and SD2.

	Chi-Square Statistic	**P value**
SD0 vs. SD1	7.256	0.027
SD0 vs. SD2	15.490	0.000
SD0 vs. SD1 + SD2	13.167	0.001

Table 22. *Chi-square test for correlation between marks and groups.*

We can conclude that the group SD0 is a stronger academic group than SD1 and SD2. This evidence makes the sample to have a built in bias, where SD0 is likely to perform better than SD1 and SD2 if they all would receive the same treatment. Put another way, the SD treatment effect on SD1 and SD2 would be harder to detect because those groups were academically weaker than the SD0 group.

The reason for the non-randomization of the sample is related to school flexibility to assign the students. At the school there were two groups per grade: 2 groups of 11th graders, 2 of 10th graders and so on. In average each group had 25 students. As we wanted to have 120 students we completed that number with students from 9th and 8th grade. The most appropriate way of assigning them was to pool the 120 students and create the groups we needed randomly from that group. However it was not the easiest way in planning terms for the school. Students from the same class would be missing different of their usual lectures as they would attend different parts of the civics activity. That situation could have been more feasible in other circumstances but the finalization of the year did not allow much flexibility in rescheduling their commitments. Another fact the contributed to the lack of randomization was the lack of time of some of the groups. The two 11th groups were the ones with the most activities to do for what they were assigned to work on the shortest lesson: the Non-SD one.

The SD0 group was not taught with the SD teaching method. The built-in bias could have made the positive effect of a SD teaching method more difficult to see in our experiment. Specifically, it may be responsible for the SD0 group having more students who improved their comprehension test scores (BIC). Moreover, when the SD1 and SD2 groups displayed larger improvement gains on the comprehension test (DIC), the lack of a statistically significant difference could be due to the built-in academic bias that favored the SD0 group. Without that bias, the difference may have been larger and we would have more confidence in that result.

5.2 Internal factors

Now let's consider the internal perspective. The present experiment used two tests to measure two different dimensions: a general understanding of the content of the lesson (Comprehension) and the change in civic attitudes students could have after understanding what the lesson was intended to teach (Attitude – Interest and Sense of Efficacy). We made use of a story about an Asian city (Naga) to situate them in a place where they could imagine the development of a participatory process. The type of questions on the comprehension test shaped three main categories: comprehension of the elements mentioned and described (through direct analogies of accumulation and flow processes), comprehension of the dynamics of the diffusion process (feedback relationships) and comprehension of how changes would affect those dynamics (policies).

Questions 1 and 2 asked for concepts linked to the Diffusion: analogies of stocks and flows. From question 3 to 7 we moved around the reinforcing loop to ask for understanding of how the variables were related. These five questions center on different variables in the loop and assume that a student would get the right answer if he can understand how the loop works. In the end they are asking for the same answer: the linkage Experience – Effectiveness – Confidence from different spots in the loop. The test had a clear purpose in each question and there were links between all the questions building a complete tool to account for the specific comprehension of the Promotion of Active Citizenship.

However we now recognize the shortcomings the Comprehension test had. In the effort of trying to be balanced with how much the students could get from the lesson we placed the level of difficulty at a low point of the scale. The idea of being active in civic issues is a thought that most of the people consider as positive and actually support when they have to talk about it. But what it takes to activate a significant portion of the population goes beyond the general idea people could have: it requires actual conviction and understanding of such a diffusion process. In questions 5, 6 and 7 the tests lack the appropriate level of difficulty. To get the correct answers they did not necessarily have to

use what they could have learnt in the lesson. The alternative answers were not strong enough to "compete" for being the right one on students' minds. The wording of the answers plus a standard level of logic to discard instead of choose (for those who did not know the answer) were factors that reduced the potential of the questions. The intention of the instrument was rigorous but the scope of the questions fell short of the students' capacity to answer. The test was in need of more creative questions that challenged students' new knowledge more than the mere direct questioning.

When considering the quality of the Attitude Test, it is important to remember that attitudinal change is related more to a process than a fact. It is not common to find a drastic change in attitude after the application of a treatment. Our aim was to influence key factors such as strong message elaboration to persuade, as the literature on attitude change reveals. For that reason we needed to elaborate a strong message (which we considered could be achieved using SD language) that could actually persuade and induce a change in attitude.

5.3 Parallel Experiment

The experiment was carried out in collaboration with the project in history of Margarita Cruz. Even when we used the same Diffusion structure to develop the instructional methods the two projects had different purposes. The history project was centered on the French Revolution. The lesson was developed using exclusively the Diffusion structure of Non-revolutionaries becoming Revolutionaries. Students studied such a structure and the behavior it shows. The goal was to teach about the spread of revolutions which could be generalized using the Diffusion structure: explain the students what variables play a role in revolutionary movements and what behavior they cause according to the connections that exist between them. It was a simplified version of that historical event that challenged students' minds by teaching them in a way did not require exclusively their memory skills (a skill that traditional teaching of history is based on). The main result of her history experiment is that the group who received the more exposure to SD showed better performance and the results were statistically significant in

most of the measures used. History results show definitely positive outcomes towards SD in the learning of revolutions. Because of the participation of the same students and the same atmosphere both experiments counted with the same external biases regarding students' attitudes, time to digest the information given the challenges of the SD method and randomization of the samples. But still the positive findings of the history experiment constitute a very important reference point to evaluate the effectiveness of the civics experiment.

From the two structures we described the civics model included, the history teaching instruction focused on one: the Diffusion. The civics however had its main interest on the second structure: the reinforcing loop of Experience – Effectiveness – Confidence. The two structures together signified more complexity for the students and it could act against the positive effects SD could contribute with.

The measurement tool used in the history project contained more questions (all of them carefully designed) which allowed evaluating more accurately students' knowledge. Even with a structure less complex, the history test was more exhaustive.

5.4 SD: Challenge of new material

The SD perspective was new for the students were, and that created an important challenge. Students had to understand the logic of new diagrams and learn how to read them. Even when they had a preliminary session which was intended to work as a motivator, it was demanding for them to approach a new perspective and to see it applied to the specific field of civics. The time limitations to conduct the experiment also increased the level of difficulty for the students. Another factor that contributed to the challenge of new material relates to students' attitudes. Their disposition to perform the way they were accustomed to in their academic activities was affected by the "finalization of the academic year" effect. That situation hindered students from being fully focused on the activity. This situation would have a greater impact on the SD1 and SD2 groups because they had to put more effort into the instructional process than the

SD0 group. It is possible that the content overloaded students' capacity to understand given the characteristics of the experiment: short time to assimilate new language and methodology (SD), instructional method using Power-point slide presentations, "end of the year" effect and attitude toward civics issues.

5.5 Lessons learned

Several lessons can be learnt from the experimental experience. The present paper works as an initial step on measuring the effects of using SD as a tool to approach civics issues. The experience with the students and the way most of them received the knowledge was motivating and inspiring. We could see an opportunity exists for the use of SD to place knowledge in the structure pattern of the mind that learns.

The model to Promote Active Citizenship has a stock of knowledge that constitutes a key building block in the contents of civics. It represents a fundamental premise to propel participatory processes because it contains explanatory variables that constitute the foundations of civic participation. When approaching and understanding how it works, citizens would know where to intervene and induct a change that would make a difference. In the end the model promotes the synergy of citizens to amplify the impact of their participation.

The model is in harmony with the political science literature regarding the positive effect of political knowledge on political participation: (1) connects personal/group interest with specific public issues; (2) creates stability of political attitudes; (3) implies high probability of voting; (4) understands political events or integrates new information into an existing framework; (5) alters citizens' views on specific public issues; (6) implies a lower likelihood to experience a generalized mistrust of, or alienation from, public life; and (7) promotes support for democratic values. The results of this experiment (summarized in Table 20 at the end of chapter 4), suggest that SD then has something to contribute with at a very basic stage of the civics education of

students. With the use of that model the promotion of healthy attitudes towards citizens' involvement is reinforced.

Four specific points of improvement we need to point out from the present experimental experience:

1. The complexity of the lesson required more time for the students to grasp effectively the knowledge the model offered. A good alternative would be to divide the lesson in different sessions to guarantee a suitable load of knowledge students would be able to digest.

2. The Comprehension test was in need of a more thorough design. Collaboration of teachers in the area of social sciences and of system dynamicists would contribute significantly to the strength of the test and its appropriateness to measure performance. It means to have a proper number of questions and more than one per "category" or "dimension" of interest. , and try to make sure of the right reasons that explain the outcomes. Getting the most out of the experimental experience requires also the hard work on the quality of the questions and the depth they reach.

3. Researcher needs to make sure of the appropriateness of the time of the year when he is going to conduct the experiment. The "end of the year effect" created a strong bias to the experiment in terms of the logistics (sample formation) and attitudes towards the experimental activities. Something similar might happen in the period before June – July holidays. At the same time the possibility of offering an incentive to the good performance of students (for instance, a good mark in the social sciences subject) is not possible at the end of the year when students would pass to another grade. Thus the choice of a more regular period of the academic year would definitely provide a more favorable atmosphere.

4. For the present experiment we made use of the language and system thinking tools (diagrams) that are one of the dimensions of SD field. However, the opportunity of

using computer simulation and Interactive Learning Environments (ILE) is also offered by SD and could strengthen its contribution on students' learning. SD not only could contribute with its conceptual tools of diagrams and language but the tool of simulation, which places the students in an active role when learning. That is the why the use of an Interactive Learning Environment (ILE) as a learner-centered methodology might enrich future research on civics using SD. SD modeling is learning by doing. It is learning through being surprised by the mistakes one makes. SD modeling is a participative activity in which one uses simulation to learn the connection between structure and behavior. (Forrester 1994)

Further research on the field would profit from the inclusion of direct communication among students themselves and between students and teachers. It could be a possible amplifier of the effective learning of civics using SD. The literature about civics teaching methods recognizes the interaction in the classroom as a factor that highly contributes to the effectiveness of civics learning. Combining strategies is also a recommendable policy. The literature supports participatory methods, stress on learning by doing and involvement of students' daily life issues.

A longer period of experience with SD would contribute with important insights. It would be ideal to follow the process of a student making sure of the comprehension of the basics of SD and then its application to civic issues.

Future efforts should also include research on the Elementary level. As (Brown 1993) stated, "progress in introducing [SD] is apparently achieved much more quickly and more economically when the effort begins in an elementary or middle school. When the change takes place first in the lower school, the students will take with them information about improved teaching practices as they move to the higher grades. They will be prepared for the more advanced study of systems that a high school should offer".

Final Comment

The present research constitutes an attempt to contribute to the learning of civics using SD. We got results that are generally consistent with our hypothesis but do not statistically confirm how effective SD could be in using the model to promote active citizenship. A critique of our methods suggests opportunities to refine the design and conduct of the experiment, the content of the lesson and the design of the measurement instrument. From the experience in the SD field, the positive results its use has meant to several other subjects on K-12 education and the literature that supports SD perspective and tools, we consider it is worthwhile to continue with SD research on civics instruction. Civics is a flexible subject that has a whole universe of topics and as a social sciences' subject places the person development and interaction as the center of the learning process. It requires a lot of reflection, research and discussion and could profit from a discipline that influences the structure of thinking of students building knowledge in a more stable way. In the end, the more meaningful knowledge students get, the healthier their social attitudes are and thus their social behavior.

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APPENDICES

A–1. T-test assumptions

The *t*-test is the most commonly used method to evaluate the differences in means between two groups. Two conditions must be met: variables must be normally distributed within each group (Normality assumption) and the variation of scores in the two groups must not be reliably different (Equality of variances assumption).

We need one independent (grouping) variable and at least one dependent variable. The means of the dependent variable are compared between selected groups based on the specified values of the independent variable.

Dependent variables: Percentage of Improvement, Normalized change and Absolute Improvement.

Independent variable: Groups (SD0, SD1, SD2)

A Levene's test is a robust way of checking the Equality of variances assumption.

H_o: $\sigma_{C1} = \sigma_{C2} = \sigma_{SD1} = \sigma_{SD2}$

H_1: $\sigma_i \neq \sigma_j$ for at least one pair (i,j); i = j = SD0, SD1, SD2

Test of Homogeneity of Variances

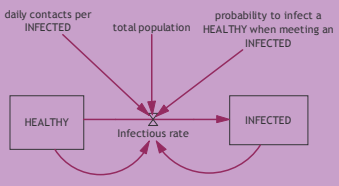
	PI	NC
Levene Statistic	1.766	0.768
P value	0.157	0.514

With values of 0.157 (Percentage) and 0.514 (c) for the significance of the Levene Statistic, which are higher than $\alpha = 0.05$, H_o can not be rejected. It can be considered then that the four groups are random samples of one single and larger group of students (all the students of the school).

The Normality assumption was guaranteed by a simple rule of thumb: when you are doing a t-test the assumption is that the distribution of the sample means are normally distributed. One way to guarantee this is for the distribution of the individual observations from the sample to be normal. However, even if the distribution of the individual observations is not normal, the distribution of the sample means will be normally distributed if your sample size is about 30 or larger. This is due to the "central limit theorem" that shows that even when a population is non-normally distributed, the

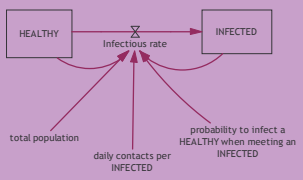
distribution of the "sample means" will be normally distributed when the sample size is 30 or more.

A–2. Systed Dynamics slide show presentation.

SLIDE 1	SLIDE 2
WELCOME TO THIS LEARNING EXPERIENCE 	This is not be the first time you approach the following content. It is very possible that at school, with your family, with your friends and in the media you hear frequently about **citizenship**, **rights**, **responsibilities** and **participation**. 
SLIDE 3	**SLIDE 4**
However, I want you to ask yourself and think: Has what you have heard regarding this had any effect on you?  *Are your attitudes and behaviour in the comunity where you belong in agreement with those ideas and campaigns you see and listen to?*	The idea is not to question your behaviour. The idea is to show you some concepts that allow you to visualize the fact of being actives in society from a dynamic point of view. It is an alive process. **Go ahead...** 
SLIDE 5	**SLIDE 6**
The process in which population passes from being poorly active to be responsibly active can be approached through a stock, flow and relationships structure that make this process **dynamic**, with **multiple influences** and highly interesting. **Let's start to study it:**	Before starting the analysis of our issue of interest, keep in mind this. During the first session in which the Infection Game was explained with the elements that generated this process, you saw a diagram like this: 
SLIDE 7	**SLIDE 8**

The position of the elements in that diagram does not modify the way how it behaves. It is just a graphical representation.

This diagram then can be represented like this:



SLIDE 9

Now let's start…

Civic Activation means the action of activating people in civic matters: pass from being a **non-activist** to being an **activist**.

It means to stop being indiferent, becaming into someone solidary, kind, heedful, diligent and with a strong willingness to perform activities of common welfare.

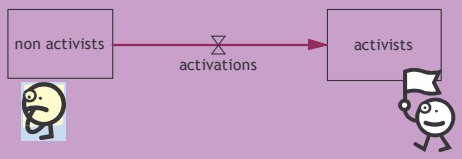
SLIDE 10

The wise Aristotle used to say "the isolated man is either a brutish or a god…"

The Greeks called "politikos" to men who were interested and participated actively in all the issues of the polis, while those who stayed apart from common issues were called "idiotikos" (idiots).

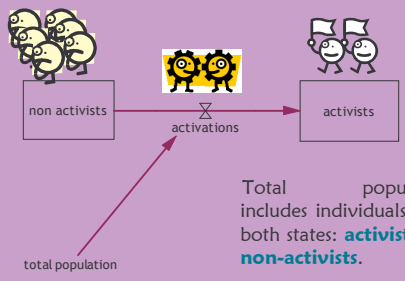
SLIDE 11

The general idea of activation implies a change and in our issue of interest there is a change of state: individuals pass from being **non-activists** to being **activists** in the society where they develop through **activations**.



SLIDE 12

The flow of **activations** substracts individuals from the state (or level) of **non-activists** to take them to the state of **activists**.



Total population includes individuals from both states: **activists** and **non-activists**.

SLIDE 13

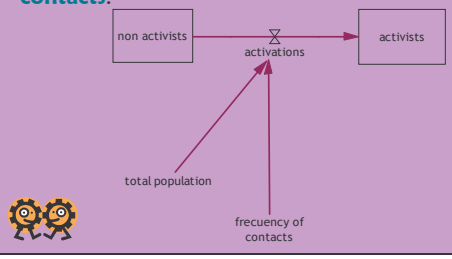
But, how does the flow **activations** work?

We can think that the decision of getting active depends on the **interaction** between activist and non-activist population. The daily life that let people get closer influences those who are non-activist. They decide to change their behavior when getting to know people who are activists.

SLIDE 14

Let's see this flow:

Each **activist** is in charge of spread the initiative of participation to those who are **non-activists**. These are the interactions or contacts that cause the diffusion of participation culture: the **frequency of contacts**.



SLIDE 15

The **frequency of contacts** of activists is the main source of the diffusion of the activation message.

Contacts that all the **activists** make with **non-activists** are the ones the make more (or less) **activations**.

These contacts with **non-activists** depend on:

1. the total number of **activists**,

2. the **frecuency of contacts** that each of them makes.

These two elements together yield the **frecuency of all the contacts**.

SLIDE 16

We also have to take into account:

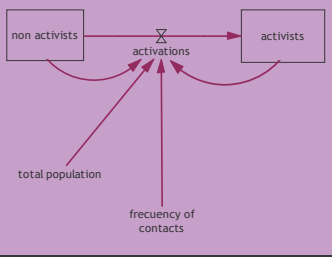
3. The quantity of **non-activists** that there are in the total population. This to know how probable is to meet one of them.

Summarizing, these three elements define the dynamics of the interaction. In other words, the quantity of contacts between all the **activists** and **non-activists**.

SLIDE 17

What was explained before is reflected in the diagram under study when we add the link between **non-activists** and **activations;**

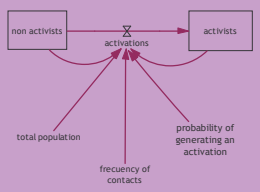
and then the link between **activists** and **activations**.



SLIDE 18

However, not all the contacts between **activists** and **non-activists** make the latter to be active.

There is a **Probability to make an activation.** It consists in the capacity **activists** have to make **non-activists** believe it is worthy to get involved.

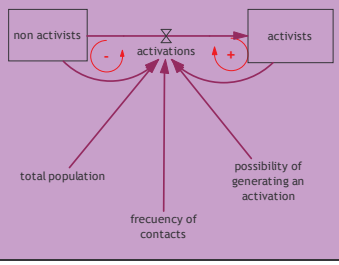


In this way to the total quantity of contacts between **activists** and **non-activists** we include how many people become activists alter the contact. The **Probability to make an activation** is added to our process.

SLIDE 19

Two loops are present in the **Civic Activation**: a positive and a negative one.

They are the ones that give life to a **dynamic behavior.**



SLIDE 20

Why a **dinamic behavior**? Because during the course of the process, the speed at which people become activists is different. This depends on which of the loops (the positive or the negative) is stronger. **Let's see it:**	At the beginning of the **Civic Activation** initiative the group of **activists** is small. As a direct campaign starts there are contacts with non-activists. At that moment there are a lot of **non-activists** in the population. **Activists** have a big probability of meeting **non-activists** because there are too many, and they say and show the purpose of a participatory attitude. If the **probability to make an activation** is high, activists will make a better work: they would convince more people.
SLIDE 21	**SLIDE 22**
Because at the beginning of the process there are many people to convince, the results are higher in number: the more the **activists**, the more the **frequency of contacts** of activists, the more the **contacts** with **non-activists** and the more the people who **become active** making bigger the group of **activists**. There is then a **positive loop** or a **reinforcing** one. It is stronger in this initial phase of the process.	As the group of **activists** is growing and the group of **non-activists** decreases, the probability of meeting a **non-activist** is smaller. The reinforcing loop looses strength due to the number of **activists** is approaching the number of people in the **population**. Contacts with **non-activists** are more scarce and for this reason there are fewer conversions: the process gets slow. At this point the **negative loop** or the **balancing** one is stronger.
SLIDE 23	**SLIDE 24**
After seeing the whole **Civic Activation** process, we can focus on two very important elements of it. When we find societies with low levels of commitment, the process of passing from being a **non-activist** to being an **activist does not exist**. The **frequency of contacts per activist** as well as the **probability to make an activation** are weak elements. It makes the flow of activations not to work.	**Why weak elements?** As there are not many **activists** (which is evident as we refer to a society with low citizen commitment), the frequency to contact **non-activists** is going to be low too. The same happens with the **probability to make a non-activist to be motivated**: it is low or even null given people are not convinced.
SLIDE 25	**SLIDE 26**

How to get this process alive?

What to do for the **activations** to start functioning?

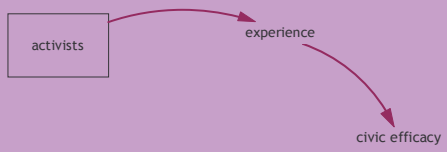
Let's think for a moment on the contrary case: when a person is committed and participates in her community.

SLIDE 27

As that person makes participatory actions, she will accumulate **experience** in civic matters: she will know how the processes work, who they should go to, how long it takes, which is the procedure to follow… in other words, she will move like a fish in the water.

SLIDE 28

That **experience** will be reflected in a higher **civic efficacy.**



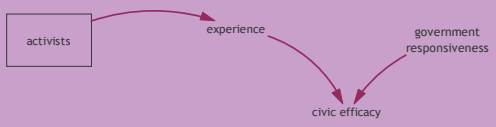
Do you know what *efficacy* is?

It is the capacity to get the desired or expected effect.

SLIDE 29

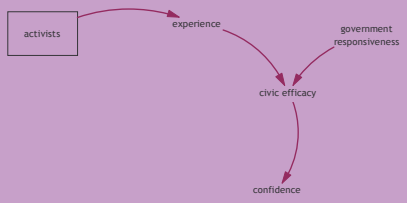
In our case, **civic efficacy** is the capacity to make participatory actions to have the desired effect in the community, in other words, more welfare as fruit of participation.

But this efficacy not only depends on the experience of those who participate but also on the environment of the institutions and governmental organisms. In other words, it depends on the **responsiveness** to participation.



SLIDE 30

When the person realizes her actions make sense and get the desired effect, she will feel more **confidence**, more comfortable with the actions performed.



From now on is where we will see all this story about an activist can help us to understand how activations are impelled.

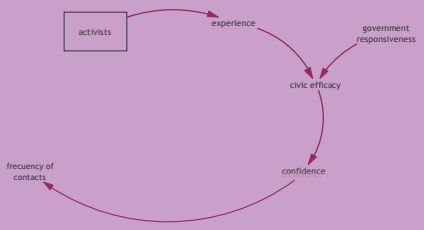
Pay attention!

SLIDE 31

As she feels more comfortable with her own actions, the activist will have more deseos to communicate her positive experience to those who are **non-activist** yet.

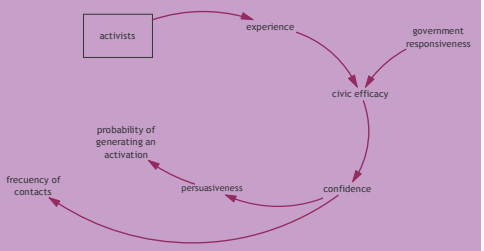
The greater **confidence** can be expressed in two ways:

1. A greater energy to contact non-activists, which is a greater **frequency of contacts**.



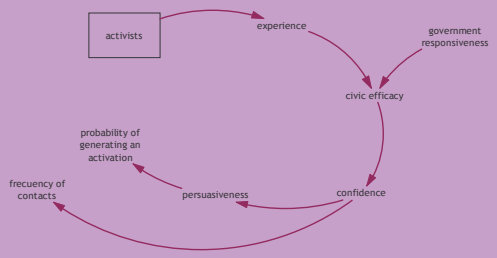
SLIDE 32

2. Each activist will have more conviction in her message, in other words, greater **persuasion**; and the greater persuasion makes higher the **probability of every activist to make an activation**.



SLIDE 33

We get then to the elements we defined as weak when we referred to a society with low citizen participation: **frequency of contacts** and **probability to make an activation**.



SLIDE 34

Let's think about the next:

A person goes through this process: she is **activist**, accumulates **experience** of participation which will make her more **effective** in her society and which will give her enough confidence to communicate the importance of commitment in her society.

If only one person goes through this, the strength of these relationships gets lost and the effect would be very weak when activating a good portion of population.

One single person can not make the difference

SLIDE 35

However…

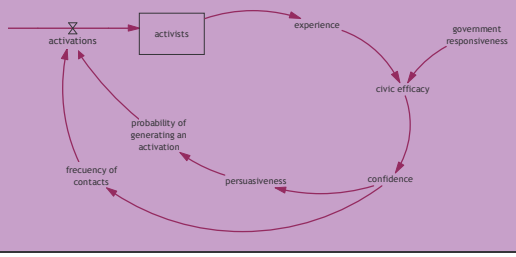
What if an important portion of the population goes through this process?

The effect would be of important proportions because when gaining **confidence** they would interact with more frequency and with more strength.

The effect could be highly strong because it is double. In other words, it is not only the **quantity** of contacts but the **quality** of them: **more** contacts with **higher intensity**.

SLIDE 36

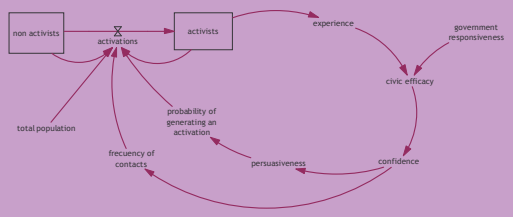
Activations then would accelerate, increasing the quantity of **activists** and starting again the accumulation of **experience.**



SLIDE 37

The whole process is present in the diagram.

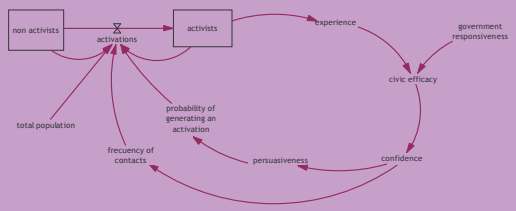
To our initial structure of **Civic Activation**, we add the elements that have the potential of making stronger the effect of the two fundamental variables: **frequency of contacts** and **probability to make an activation**.



SLIDE 38

For you to see it more clearly:
This is the structure of **Civic Activation.**

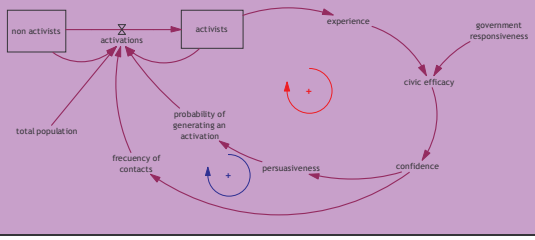
We link the elements that strength this process:



SLIDE 39

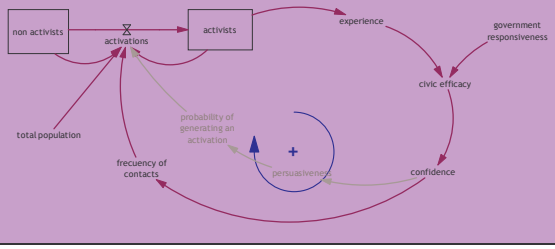
Being **activists** implies to gain **experience**, which after a long process affects the quantity of **activists**.

This feedback relationship (meaning that the element that affects is also affected) is shaped by two reinforcing loops.



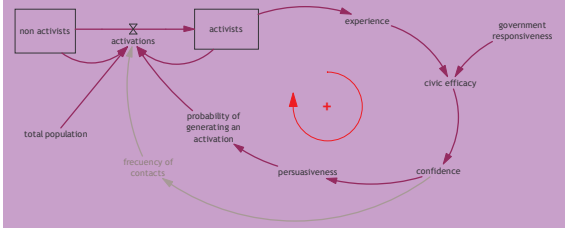
SLIDE 40

The first loop includes the effect of the **frequency of contacts**: a higher number of **activists** makes more **experience** to accumulate. It makes higher the **efficacy** of individuals which increases **confidence** and in this way the communication of that experience to activate more people also increases.



SLIDE 41

The other loop arises from the **probability to make an activation** (the quality of contacts): as the individual gains more **confidence** in her own capacities when participating, she will be more confident when communicating her experience to others and this increases the **probability to active another person**, which increases the **activations** and therefore the **activists**.



SLIDE 42

After seeing the way how these elements relate to each other and create a system, a dynamic structure, it is fundamental you get your own conclusions and ask yourself if what you have seen contributes to your comprehension of this social process.

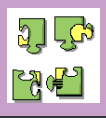
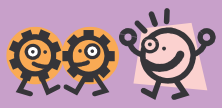
SLIDE 43

We saw two big processes: the process of **Civic Activation**, where population decides to commit in matters of common welfare. This process needs an impulse, a force that brings dynamics to the activations. Here is where the second process appears: the one that shows how the **experience** generates **efficacy** which in last accounts for **confidence**.

Confidence for what?

To activate more persons.

SLIDE 44

You actually can make the difference if a big quantity of members from your community decide that each of them can make the difference. **That is the key point!!** 	As you read at the beginning it is posible that part of this information you received was not the first time you saw it. But for sure you had not seen it in this way. The important thing is this: *Only from the comprehension of our reality we have the capacity to suggest solutions.* *It is not possible to fix a problem we do not know.*
SLIDE 45	
THANK YOU VERY MUCH FOR YOUR ATTENTION!  **Please ask for the test to the person in charge**	

A–3. Non SD slide show presentation.

SLIDE 1	SLIDE 2
WELCOME TO THIS LEARNING EXPERIENCE 	This is not be the first time you approach the following content. It is very possible that at school, with your family, with your friends and in the media you hear frequently about **citizenship**, **rights**, **responsibilities** and **participation**. 
SLIDE 3	**SLIDE 4**
However, I want you to ask yourself and think: Has what you have heard regarding this had any effect on you?  *Are your attitudes and behaviour in the comunity where you belong in agreement with those ideas and campaigns you see and listen to?*	The idea is not to question your behaviour. The idea is to show you some concepts that allow you to visualize the fact of being actives in society from a dynamic point of view. It is an alive process. **Go ahead...** 
SLIDE 5	**SLIDE 6**
Now let's start… **Civic Activation** means the action of activating people in civic matters: pass from being a **non-activist** to being an **activist**. It is to stop being indiferent, becaming into someone solidario, kind, atento, diligente and with a strong willingness to perform activities of common welfare. 	The wise Aristotle used to say "the isolated man is either a brutish or a god…"  Aristotle The Greeks called "politikos" to men who were interested and participated actively in all the issues of the polis, while those who stayed apart from common issues were called "idiotikos" (idiots). 
SLIDE 7	**SLIDE 8**

The general idea of activation implies a change and in our issue of interest there is a change of state: individuals pass from being **non-activists** to being **activists** in the society where they develop through **activations**.

Activations substracts individuals from the **non-activists** to take them to the **activists**.

SLIDE 9

But, how do those **activations** work?

We can think that the decision of getting active depends on the **interaction** between activist and non-activist population. The daily life that let people get closer influences those who are non-activist. They decide to change their behavior when getting to know people who are activists.

SLIDE 10

Each **activist** is in charge of spread the initiative of participation to those who are **non-activists**. These are the interactions or contacts that cause the diffusion of participation culture: the **frequency of contacts**.

SLIDE 11

The **frequency of contacts** of activists is the main source of the diffusion of the activation message.

Contacts that all the **activists** make with **non-activists** are the ones the make more (or less) **activations**.

These contacts with **non-activists** depend on:

1. the total number of **activists**,

2. the **frecuency of contacts** that each of them makes.

These two elements together yield the **frecuency of all the contacts**.

SLIDE 12

We also have to take into account:

3. The quantity of **non-activists** that there are in the total population. This to know how probable is to meet one of them.

Summarizing, these three elements define the dynamics of the interaction. In other words, the quantity of contacts between all the **activists** and **non-activists**.

SLIDE 13

However, not all the contacts between **activists** and **non-activists** make the latter to be active.

There is a **Probability to make an activation.** It consists in the capacity **activists** have to make **non-activists** believe it is worthy to get involved.

In this way to the total quantity of contacts between **activists** and **non-activists** we include how many people become activists alter the contact. The **probability to make an activation** is added to our process.

SLIDE 14

Civic Activation is characterized by a **dynamic behaviour**

Why?

Because in the course of the process, the speed at which people become activists is different.

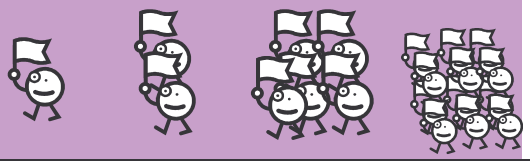
SLIDE 15

At the beginning of the **Civic Activation** initiative the group of **activists** is small. As a direct campaign starts there are contacts with non-activists. At that moment there are a lot of **non-activists** in the population. **Activists** have a big probability of meeting **non-activists** because there are too many, and they say and show the purpose of a participatory attitude.

If the **probability to make an activation** is high, activists will make a better work: they would convince more people.

SLIDE 16

Because at the beginning of the process there are many people to convince, the results are higher in number: more people are joining the group of **activists**.



SLIDE 17

As the group of **activists** is growing and the group of **non-activists** decreases, the probability of meeting a **non-activist** is smaller.

The reinforcing loop looses strength due to the number of **activists** is approaching the number of people in the **population**. Contacts with **non-activists** are more scarce and for this reason there are fewer conversions: the process gets slow.

After getting slowly, the process stabilizes as it reaches the maximum of people there are in a community.

SLIDE 18

We can focus now on two very important elements of the process described.

When we find societies with low levels of commitment, the process of passing from being a **non-activist** to being an **activist does not exist**. The **frequency of contacts per activist** as well as the **probability to make an activation** are weak elements. It makes activations not to work.

SLIDE 19

Why weak elements?

As there are not many **activists** (which is evident as we refer to a society with low citizen commitment), the frequency to contact **non-activists** is going to be low too. The same happens with the **probability to make a non-activist to be motivated**: it is low or even null given people are not convinced.

SLIDE 20

¿How to get this process alive?

What to do for the **activations** to start functioning?

Let's think for a moment on the contrary case: when a person is committed and participates in her community.

SLIDE 21

As that person makes participatory actions, she will accumulate **experience** in civic matters: she will know how the processes work, who they should go to, how long it takes, which is the procedure to follow… in other words, she will move like a fish in the water.

That **experience** will be reflected in a higher **civic efficacy.**

Do you know what *efficacy* is?

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In our case, **civic efficacy** is the capacity to make participatory actions to have the desired effect in the community, in other words, more welfare as fruit of participation.

But this efficacy not only depends on the experience of those who participate but also on the environment of the institutions and governmental organisms. In other words, it depends on the **responsiveness** to participation.

When the person realizes her actions make sense and get the desired effect, she will feel more **confidence**, more comfortable with the actions performed.

SLIDE 23

From now on is where we will see all this story about an activist can help us to understand how activations are impelled.

Pay attention:

As she feels more comfortable with her own actions, the activist will have more intentions to communicate her positive experience to those who are **non-activist** yet.

SLIDE 24

Why weak elements?

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Can you see it is a closed process? In other words, the element that affects is also affected.

Being **activists** means to gain **experiencie**, which after a long process affects the number of activists.

SLIDE 28

We finish then the discussion of our issue.

It is time for you to get your own conclusions and ask yourself if what you have seen contributes to your comprehension of this social process.

SLIDE 29

We saw two big processes: the process of **Civic Activation**, where population decides to commit in matters of common welfare. This process needs an impulse, a force that brings dynamics to the activations. Here is where the second process appears: the one that shows how the **experience** generates **efficacy** which in last accounts for **confidence**.

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SLIDE 30

Take into account:

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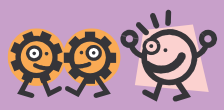


Please ask for the test to the person in charge

A–4. In-Service training session slide show presentation.

SLIDE 1

EXPERIMENTS AND SYSTEM DYNAMICS

By:
Maria Teresa González
Margarita Cruz
Maria del Pilar Restrepo

SLIDE 2

What are we learning today?

- What is System Dynamics?
- Concepts of System Dynamics
- Who are interested in System Dynamics?
- The Infection Game
- Other examples
- Experiments

SLIDE 3

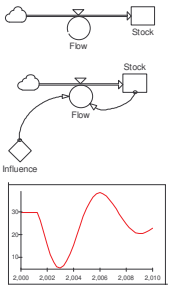
WHAT IS SYSTEM DYNAMICS?

- It is a field of study that provides a philosophy and tools to model and analyze complex systems.
- It helps to improve the process of decision making.
- It provides generic structures that help to improve the learning of different fields of study.

SLIDE 4

Concepts of System Dynamics

- Stocks and Flows
- Feedbacks and multiple influences
- Non linearities
- Delays



SLIDE 5

The more the complexity of a system, the higher the probability of making wrong decisions.

SLIDE 6

Who are interested in SD?

Those who want to face appropriately the complexity of the world in which we live

- Education stablishments
- Researches
- Governments
- Companies
- Consultancy firms

SLIDE 7

SLIDE 8

The Infection Game

Instructions

- Head or Tail.
- There is one infected person at the beginning.
- Every person makes one contact per "day".
- The infection spreads when shaking hands with an INFECTED person.
- When an INFECTED contacts a SUSCEPTIBLE, there is a chance of transmiting the disease.
- Please, fill in the sheet every "day" of the game.

SLIDE 9

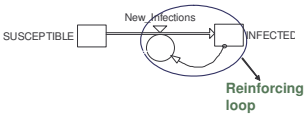
The Infection Game:
Stocks and Flows

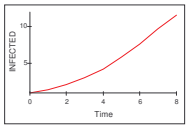
The INFECTED appear through NEW INFECTIONS. When a SUSCEPTIBLE is infected he becomes into an INFECTED.

SLIDE 10

The Infection Game:
Feedbacks and multiple influences

The INFECTED are the agents who cause the infection to SUSCEPTIBLES.

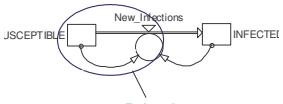


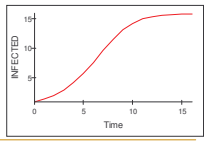


SLIDE 11

The Infection Game:
Feedbacks and multiple influences

After a while there are so many INFECTED than there are just a few SUSCEPTIBLES to infect.



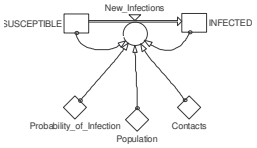


SLIDE 12

The Infection Game:
Feedbacks and multiple influences

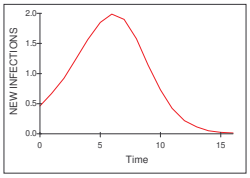
The quantity of NEW INFECTIONS depends on:

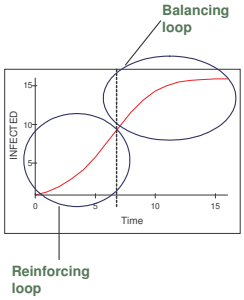
- How many individuals make contact with every INFECTED.
- The chance to create a contagion every time there is a contact.
- Population
- SUSCEPTIBLE
- INFECTED



SLIDE 13

The Game of Infection:
Dynamic over time





SLIDE 14

What did we learn of the Game?

- The spread of a disease is not a constant process.
- The initial phase of the disease requires more attention than the last one, if the goal is to provent future contagions.
- Taking prevention measures is needed in the first contagious contacts.

SLIDE 15

Other cases

- The diffusion of a rumor.
- The acceptance of a new product in the market.
- Believers of a religion.

…

- Do you find more?

SLIDE 16

Experiments

- Students from 9th, 10th and 11th grade.
- Instruction to the students in the areas of civics, history and physics, based on System Dynamics.
  - The Infection Game
  - Instructional method in the computer.
  - Pre and post tests.

SLIDE 17

THANK YOU!!

SLIDE 18

A–5. Preliminary session: SD concepts and Infection game

SLIDE 1

LEARNING WITH SYSTEM DYNAMICS

Margarita Cruz
Maria Teresa González

SLIDE 2

What will we learn today?

- What is System Dynamics?
- Basic Concepts of System Dynamics
- The Infection Game

WELCOME

SLIDE 3

What is System Dynamics?

- System Dynamics is a method to increase the understanding and learning of complex systems.
- It is composed of a philosophy and tools in order to analyze and model the systems under study.
- It enhances the decision making process.
- It provides generic structures that help to improve the learning process of different fields of study.

SLIDE 4

Basic Concepts of System Dynamics

In the study of systems it has been designed a language of concepts which are relevant for their understanding. In this presentation we will approach two of them:

- Stock and Flows
- Feedback loops

SLIDE 5

Stock and Flows

Think of a bathtub with water.

- The bathtub **accumulates** the water according to the passing by of the time. The amount of water in the bathtub is called **stock**. It is represented with a rectangle.

=

Water in the Bathtub

SLIDE 6

Stock and Flows

- The **stock** of water in the bathtub **increases** when the faucet is open. The amount of water that **flows** can be controlled by the faucet.

SLIDE 7

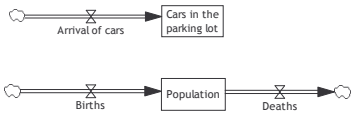
SLIDE 8

Stock and Flows

- An **inflow**, of water in this case, is represented by an arrow going to the **stock**, with a **valve** or faucet that determines the **speed** of the water that is added to the bathtub.

SLIDE 9

- According to this, it can be concluded that the water in the bathtub is a **stock** and the **flow** of water is the **rate** which **changes** such **stock**. Thus, the stocks can only be affected by the flows.
- Other examples:



SLIDE 10

Feedback Loops

- The system reacts to the solutions: yesterday's solution could be today's problem.
- The relationships are not only in one way: the result of our actions defines the situations we must face in the future.

SLIDE 11

Feedback Loops

There are two types of feedback loops:

- Positive: they are reinforcing loops.

- Negative: they are balancing or counteracting loops.

SLIDE 12

The Infection game

Have you thought before why when someone of the group catches a virus, this is transmitted to the group left?

The Infection game is an activity which will lead us to understand how the diseases –and all the diffusion phenomena- are spread from "one person" to another.

SLIDE 13

Instructions

- Choose between head or tail
- Only one person is infected at the beginning
- Every person has one "contact" per day
- The disease is probably transmitted when shaking hands with an INFECTED.
- When an INFECTED shakes hand with a HEALTHY, it is probable that the disease is transmitted.
- A contact could produce and infection when the daily result of the coin is the same side than those who are already infected.
- Fill out in the sheet of paper the information that is required.

SLIDE 14

SLIDE 15

Now, let's apply the concepts of System Dynamics

Accumulations: Stocks

- There are two big groups of people: INFECTED and HEALTHY PEOPLE.
- Each of these groups accumulates people that have a different health state, therefore, these groups may be considered as stocks.
- Stock of HEALTHY people and stock of INFECTED ones.

SLIDE 16

Changing State: Flows

- When HEALTHY and INFECTED shake hands among them Becoming infected occurs

From the diagram we can see:

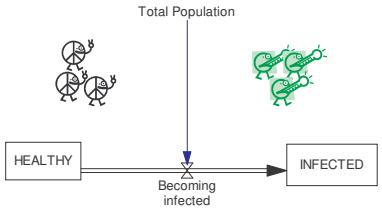
- Inflow: the more Becoming infected the more INFECTED people.
- Outflow: the more Becoming infected the less HEALTHY people.

SLIDE 17

But, how does Becoming infected work?

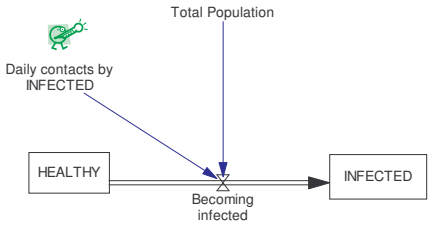
Feedback Loops and Multiple Influences (1)

- Population is split into two big groups: HEALTHY PEOPLE and INFECTED PEOPLE.
- Total Population = HEALTHY + INFECTED



SLIDE 18

2. Daily Contacts: Every day there is only one chance of shaking hands with only one person.



SLIDE 19

And how many contacts are done between HEALTHY and INFECTED?

Contacts done by INFECTED are responsible for the spread of the disease. It is important to consider:

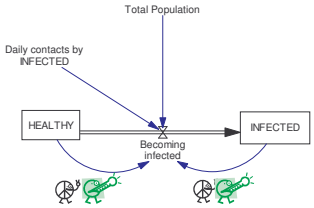
- Number of INFECTED
- Daily contacts per INFECTED
- HEALTHY proportion (equal to the Number of HEALTHY divided by Total Population) shows how many people in the population are susceptible to be infected.
- The number of contacts between INFECTED and HEALTHY are the result from the encounters between them.

Total contacts between HEALTHY and INFECTED = Daily contacts per INFECTED * # INFECTED * HEALTHY proportion

SLIDE 20

This equation leads us to complete the diagram through the consideration of a relationship between HEALTHY and Becoming infectious, and another relationship between INFECTED and Becoming infectious:

- The more HEALTHY in the population, the more contacts between HEALTHY and INFECTED.
- The more HEALTHY shaking hands with INFECTED, the more Becoming infectious.

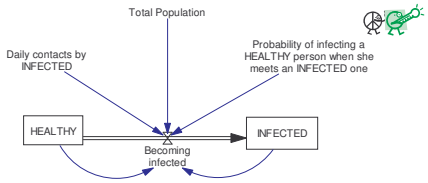


SLIDE 21

2. Probability of Contagion

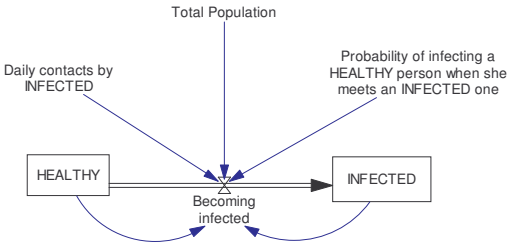
Now, what tell us about how Becoming infectious work is:

- Number of contacts between HEALTHY and INFECTED.
- The probability that someone may be infected: depends on the side of the coin which is thrown daily.
- When a coin is thrown to the air there is an equal probability on favor of Head or Tail. Thus, the probability of getting a "Head" is 0.5
- Consequently, there is equal chance that someone gets infected or not.



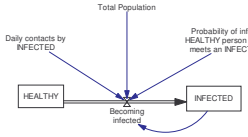
SLIDE 22

Now, from this structure let's analyze how the spread of the disease was carried through.



SLIDE 23

Strong Infection Loop: Strengthening the Contagion



This feedback loops motivates the spread of the disease initially.

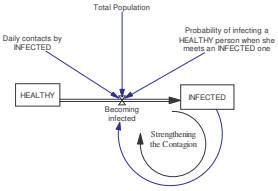
At the beginning of the game there is only one infected person who in the first day has the chance of shaking hands with someone else in the classroom. In this first day, it is always with a HEALTHY person.

When shaking hands, there is a probability of infecting only if the coin tossed by the Director of the game is on favor of the side that the INFECTED one had.

If there is infection in this day, there is one more infected person, increasing the size of the group of INFECTED people and decreasing the group of HEALTHY PEOPLE.

SLIDE 24

Strong Infection Loop: Strengthening the Contagion



Let's imagine what would happen if those who are INFECTED infect those who are HEALTHY?

The more infected people, the more contacts between HEALTHY and INFECTED. This provokes that more HEALTHY ones are contacted by INFECTED.

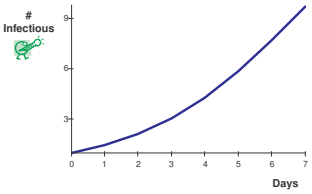
When the coin is on favor of those who are already infected, Becoming infectious occurs provoking again new INFECTED people.

This situation is repeated day after day, as time passes by there are more INFECTED people and so, more people will get infected in every day.

SLIDE 25

Strong Infection Loop: Strengthening the Contagion

- For this reason, the disease is spread quite quickly during its initial stage.
- This quick spread of the disease gives rise to a behavior well known as **exponential behavior**, in which the growth of an issue is in a exaggerated way and every time the current growth is higher than the one that occurred previously.
- In the Infection Game, as time passed by there were more INFECTED people than those that were infected in the day before, this because of every day there were more INFECTED people in the classroom.



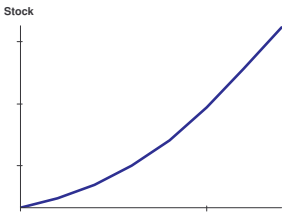
This graph shows the number of INFECTED that were every day. This group of people grew more and more with the time.

SLIDE 26

Other examples of Exponential Behavior

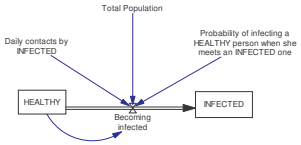
• Reproduction of bacteria in the food: once a bacteria has been in touch with the food, it reproduces quite fast and after a couple of hours the food is full of bacteria.

• Purchase of new products: once the product enters a market after a long expectations on it, many people tend to buy it quickly before it is sold out in the stores.



SLIDE 27

Balancing the Infection Loop: Weakening the Contagion



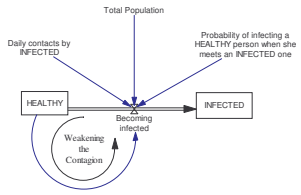
This feedback loop is responsible for the loss of production of Becoming infectious people over time.

When there are many INFECTED there are few HEALTHY as well, thus at this stage of the game when an INFECTED shakes hands with someone else, it is more probable that he meets an INFECTED rather than a HEALTHY, therefore Becoming infectious people are not produced anymore.

Since there are no more people Becoming infectious, the number of INFECTED remains constant over time.

SLIDE 28

Balancing the Infection Loop: Weakening the Contagion



If the INFECTED people shake hands with one of the few HEALTHY ones that are still in the population, then it is generated one less HEALTHY and one more INFECTED. However, due to there are few HEALTHY left, there are just a few meetings that occur after a while between HEALTHY and INFECTED.

This cycle is repeated day after day until there are no more HEALTHY to infect.

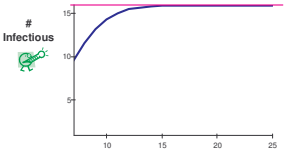
SLIDE 29

Balancing the Infection Loop: Weakening the Contagion

•The disease then is spread in a slow manner after a while.

• This slow/null spread of the disease gives raise to a behavior well known as **Goal Seeking**, in which the growth of an issue slows down as it approaches its target.

• In the Infection Game, after a while (approximately 8 days) there are produced les and less infections every day and so, the group of INFECTED kept on growing but in a slow manner now.



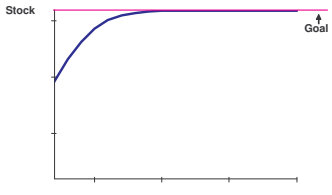
This graph shows us that after the 8th day, the group of infected grew slowly until the point of not having people there.

SLIDE 30

Other Examples of Goal Seeking

• Filling a bucket with water: when a bucket is started to be filled with water the faucet is opened widely, but once the bucket is about to be completely filled, the faucet is closed slowly to not pour the water out of the bucket.

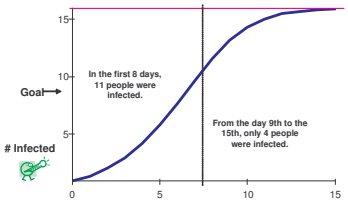
• Working on a project for school: once a school project is started and there are still some days until its deadline, students put fewer efforts and they finish it slowly.



SLIDE 31

Joining these two behaviors gives raise to an S-shaped growth

• This behavior is characterized by a very quick and exaggerated one in its initial stage. After a while it becomes slower as soon as the desired state is approached.



SLIDE 32

Conclusion

- The spread of a disease is not a constant process: exponential growth, goal seeking and stable at the end.
- The initial stage of infection requires more attention than the final one, in order to prevent more infections among the entire population.
- Preventive strategies must be applied at early stages of a disease.

THANKS!!!

A–6. Comprehension test.

THE CITY OF NAGA, FROM THE PHILIPPINES

Naga is a small city in the Philippines. In the 80's it was faltered: unemployment was rising and there was no trust to create businesses, besides the collection of taxes was going down. The situation impacted the basic services, especially in the area of health and education. Crime was growing and approximately the 20% of the population lived on the streets.

The initiative of the Government of Information of Naga city is a program of popular management that promotes transparence, an appropriate responsibility and participation looking for strengthening the processes of government and the supply of local services. The program uses different media such as "The Guide of the citizenship", Internet, printed and broadcasting tools as well as emails, to empower citizens and commit them actively in the elaboration of government policies, as well as in the implementation and evaluation of programs.

To get the spread of the initiative, the Government trained small groups of the population. They were told what the objective was, what to do and how to do it. They were encouraged to try the different media and to intervene in public policies and programs.
The idea was the citizenship itself to talk about it with their relatives, friends, colleagues and others, and after that try it. The more people who tried it and realized about the good results of it, the more people those who just got active contacted to communicate the benefits of it and the way it worked. The continuous use of the media and the responsiveness of the government made the participation itself a very effective action which empowered the citizens and gave them confidence. So not only more and more people were contacted every time, but also the initiative was strong enough and with good results to facilitate to believe and trust.

NAGA gradually overcame its problems and in 1990 it was considered one of the cities with more growth and where the life was better, besides it became in a model for the Philippine government, due to its effective and innovative programs. The key to maintain these programs is the emphasis in the participation mechanisms. Actually, the city made a lot of efforts to commit the community in the process of the government.

The more participation by the ordinary citizens is one of the most especial characteristics of Naga government, which is called Government-I.

Asiaweek referred to Naga, in November 1999, as one of the most vigorous cities of Asia, recognizing its process of participation together with its traditions strongly democratic and the commitment by excellence. The mayor Jesse Robredo received an award for "giving credit to the promise of democracy" showing that the effective administration of a city is compatible with the increase of power of its inhabitants.

QUESTIONS

Now, imagine how the process of activating the population of Naga in the use of the media was. People who joined the initiative are called **activists** and those who did not are called non **activists**. With that process in your mind, answer the following questions:

1. Which relationship below is most like the relationship between non-activists and activists?

a) Men and Women
b) Business owners and Factory workers
c) Homes without a computer and homes with computer
d) Using a credit card to make purchases and using cash to make purchase

2. The relationship you find between activists and activations is similar to the one that you find between:

a) People who believe in God and conversions
b) Orders of pizza and Deliveries of pizza
c) People who got a disease and Vaccinations
d) Number of chickens in a farm and Meals that include chicken in a farm.

3. Which relationship below is an example of the relationship between the number of activists and their frequency of participation?

a) the number of students in the school and the frequency that each student attends school.
b) the number of homes with a computer and the frequency of computer commercials on television.
c) the number of mothers in a nation and the frequency that mothers give their children a goodnight kiss.
d) the number of high-achieving students in a class and the frequency that each student joins in class discussion.

4. Which relationship below is an example of the relationship between the number of activists and their possibility of getting some to become active?

a) supporters of a soccer team and probability of winning a match
b) housewives who use a special brand of washing powder and probability of convincing other housewives of using it
c) candidates to be major of the city and probability of getting elected
d) students who got graduated from college and probability of getting a good job

5. As the number of citizens involved in civic affairs increases, that

a) encourages others to get involved because everyone wants to be involved.

b) discourages others from getting involved because they know that activism is not effective.
c) encourages others to get involved if they can see that activism is effective.
d) has not effect on others.

6. As activists use media frequently enough:

a) they gain confidence because there are few others who do it and for them it is important to be original
b) they get discouraged because it is difficult to use the media tools
c) they gain confidence because they see that using the media has an impact on their environment
d) they gain confidence because there are many others who are doing the same

7. As activists gain confidence on the importance of participating:

a) their arguments to convince others are stronger because they really believe in what they are doing and it is reliable
b) their arguments to convince others are not appreciated because the rest of the people see them as servile people
c)their arguments to convince other are stronger because it is well seen to use such modern tools
d) their arguments to convince others do not change

A–7. Attitude test.

Name _____ Grade _____

School _____

Date _____

In the table below you will find several assertions. Your objective is to mark with an "X" the cell that represents your position regarding the respective sentence. Please answer with the greatest honesty possible.

	1 Strongly disagree	**2 Disagree**	**3 Not sure**	**4 Agree**	**5 Totally agree**
1. I feel disconnected from the world around me.					
2. I think I can make the difference in my society.					
3. Puedo decir con firmeza a un compañero o compañera que lo que está haciendo no está bien para la sociedad cuando esté actuando de esa manera.					
4. Being citizens is only related to civil actions such as voting, participating in political groups and parties, being politician, etc.					
5. My family and I have a role to play as citizens in our society.					
6. Children and young people must wait until they grow up to behave as citizens.					

	1 Strongly disagree	2 Disagree	3 Not sure	4 Agree	5 Totally agree
7. Following the coexistence and participation rules can influence the society in which I live.					
8. Only if enough people play their role of citizens will society be influenced.					
9. I enjoy conversations and discussions about participation and citizen engagement.					
10. I am interested in knowing my rights and responsibilities as a citizen.					
11. I think I would enjoy being part of campaigns that promote civil engagement and participation.					

A-8 Raw data

Comprehension data

Pretest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct answers		C	A	D	B	C	C	A
Group	Student							
SD0	**1**	C	A	B	B	A	C	D
SD0	**2**	D	A	D	A	D	C	A
SD0	**3**	C	A	A	B	B	C	A
SD0	**4**	B	A	A	C	A	B	C
SD0	**5**	D	D	A	B	C	D	A
SD0	**6**	B	C	A	A	C	C	A
SD0	**7**	B	C	A	B	D	C	A
SD0	**8**	C	A	A	C	A	A	D
SD0	**9**	C	D	A	B	A	C	A
SD0	**10**	D	B	C	C	A	C	D
SD0	**11**	B	B	A	B	B	C	D
SD0	**12**	D	A	A	B	C	A	C
SD0	**13**	C	B	A	D	C	C	A
SD0	**14**	C	A	B	B	A	C	A
SD0	**15**	D	A	A	B	A	D	D
SD0	**16**	C	A	A	B	C	C	A
SD0	**17**	B	A	A	C	C	C	A
SD0	**18**	B	C	A	B	D	C	A
SD0	**19**	C	A	A	D	C	C	A
SD0	**20**	B	C	A	C	C	C	D
SD0	**21**	C	A	A	B	C	C	A
SD0	**22**	D	A	D	B	C	C	A
SD0	**23**	C	A	A	D	C	C	A
SD0	**24**	C	A	C	A	C	A	A
SD0	**25**	C	D	D	B	C	C	A
SD0	**26**	B	C	A	A	C	C	A
SD0	**27**	B	A	A	B	C	E	A
SD0	**28**	C	A	A	B	B	C	C
SD0	**29**	C	D	A	B	A	C	A
SD0	**30**	C	C	A	A	C	C	A

Pretest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct answers		C	A	D	B	C	C	A
Group	Student							
SD0	**31**	C	C	C	B	C	C	A
SD0	**32**	B	A	D	B	C	C	A
SD0	**33**	B	C	B	A	A	C	A
SD0	**34**	C	A	C	A	A	C	A
SD0	**35**	A	D	C	A	A	D	B
SD0	**36**	D	A	A	B	C	A	C
SD0	**37**	C	A	A	D	B	B	A
SD0	**38**	B	C	C	B	C	D	B
SD0	**39**	C	C	A	A	A	C	A
SD0	**40**	B	C	A	B	A	B	A
SD0	**41**	D	B	D	A	C	A	B
SD0	**42**	C	C	A	B	A	A	A
SD0	**43**	C	A	A	C	C	C	A
SD0	**44**	B	C	C	D	A	B	A
SD0	**45**	D	D	B	A	D	A	B
SD0	**46**	C	B	B	A	C	A	C
SD0	**47**	B	A	A	C	C	C	A
SD0	**48**	B	B	A	D	B	A	C
SD0	**49**	B	A	A	A	C	C	A
SD0	**50**	C	C	A	B	C	C	A
SD0	**51**	B	B	A	D	B	A	A
SD0	**52**	C	D	A	B	D	B	A
SD0	**53**	B	A	A	B	C	C	C
SD0	**54**	C	D	A	B	A	C	A
SD0	**55**	C	A	C	B	A	C	C
SD0	**56**	C	A	D	A	C	B	D
SD0	**57**	C	A	A	B	B	C	C
SD0	**58**	B	D	C	A	B	D	A
SD0	**59**	D	A	D	B	C	C	A
SD0	**60**	B	C	D	A	A	A	C

Posttest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct answers		C	A	D	B	C	C	A
Group	Student							
SD0	**1**	C	A	B	B	C	C	D
SD0	**2**	C	B	A	D	C	C	A
SD0	**3**	B	A	A	B	B	C	A
SD0	**4**	B	A	A	B	B	C	A
SD0	**5**	D	D	A	B	C	C	A
SD0	**6**	B	A	A	B	C	C	A
SD0	**7**	B	C	A	B	A	C	A
SD0	**8**	B	C	A	D	A	A	A
SD0	**9**	B	A	D	B	A	C	A
SD0	**10**	D	B	A	C	D	C	D
SD0	**11**	D	B	B	A	A	C	A
SD0	**12**	D	A	A	B	C	A	A
SD0	**13**	C	B	A	B	C	C	A
SD0	**14**	D	A	B	B	A	C	A
SD0	**15**	D	A	A	C	A	D	D
SD0	**16**	C	A	A	B	C	C	A
SD0	**17**	B	A	C	C	C	C	A
SD0	**18**	B	C	A	B	D	C	A
SD0	**19**	C	A	A	D	C	C	A
SD0	**20**	B	C	A	C	C	C	A
SD0	**21**	C	A	A	A	C	C	A
SD0	**22**	D	A	D	B	C	C	A
SD0	**23**	C	A	A	B	C	C	A
SD0	**24**	B	C	A	C	D	C	C
SD0	**25**	B	D	D	B	A	C	B
SD0	**26**	C	C	A	B	C	C	A
SD0	**27**	B	A	A	B	A	C	A
SD0	**28**	C	A	A	B	D	C	A
SD0	**29**	C	D	A	B	A	C	A
SD0	**30**	D	D	A	A	C	C	A

Posttest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct answers		C	A	D	B	C	C	A
Group	Student							
SD0	**31**	C	A	C	B	C	C	A
SD0	**32**	B	A	A	B	C	C	A
SD0	**33**	A	B	C	B	C	D	B
SD0	**34**	C	A	C	A	A	C	A
SD0	**35**	B	A	B	A	A	C	C
SD0	**36**	D	A	D	C	A	A	A
SD0	**37**	C	A	A	B	C	C	A
SD0	**38**	C	B	C	B	C	C	A
SD0	**39**	C	A	A	B	A	C	C
SD0	**40**	B	B	A	C	C	A	B
SD0	**41**	B	B	C	D	D	B	B
SD0	**42**	D	B	A	B	A	C	A
SD0	**43**	C	A	A	C	C	C	A
SD0	**44**	B	C	A	B	A	A	A
SD0	**45**	B	C	A	A	C	C	C
SD0	**46**	C	A	B	A	C	A	A
SD0	**47**	C	B	C	B	C	C	A
SD0	**48**	A	A	A	C	A	B	C
SD0	**49**	B	A	A	B	B	A	A
SD0	**50**	C	A	A	A	C	C	C
SD0	**51**	C	A	A	B	C	A	A
SD0	**52**	C	B	C	D	A	A	B
SD0	**53**	A	A	A	B	B	A	A
SD0	**54**	C	D	A	B	D	C	A
SD0	**55**	C	A	A	B	C	C	C
SD0	**56**	A	A	A	B	A	B	D
SD0	**57**	C	C	B	B	A	C	C
SD0	**58**	B	A	C	A	A	B	D
SD0	**59**	B	A	A	B	C	C	A
SD0	**60**	A	B	C	B	C	B	B

Pretest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct Answers		C	A	D	B	C	C	A
Group	Student							
SD1	1	C	B	A	B	D	C	A
SD1	2	C	C	A	B	A	C	A
SD1	3	B	C	D	A	A	C	A
SD1	4	C	A	A	B	A	C	A
SD1	5	B	C	A	B	A	C	A
SD1	6	C	A	A	B	C	C	A
SD1	7	D	C	A	B	A	C	A
SD1	8	C	A	D	B	A	C	A
SD1	9	C	C	A	B	C	A	A
SD1	10	C	B	A	B	A	C	A
SD1	11	C	A	A	B	D	C	A
SD1	12	C	A	A	B	C	C	A
SD1	13	C	A	A	B	A	C	A
SD1	14	C	B	A	B	C	C	A
SD1	15	C	B	A	B	D	A	A
SD1	16	C	A	A	B	C	C	A
SD1	17	C	B	D	B	C	C	A
SD1	18	C	A	A	B	A	C	A
SD1	19	C	B	D	B	C	C	A
SD1	20	C	A	D	B	C	C	A
SD1	21	C	A	A	B	C	C	A
SD1	22	C	A	A	B	D	C	D
SD1	23	C	A	A	B	A	C	A
SD1	24	C	B	D	B	B	D	A
SD1	25	C	A	A	B	C	C	A
SD1	26	C	B	D	B	B	C	E
SD1	27	C	A	A	B	B	C	C
SD1	28	C	A	D	B	A	C	A
SD1	29	A	A	B	C	A	A	A
SD1	30	B	D	D	B	C	C	A

Posttest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct Answers		C	A	D	B	C	C	A
Group	Student							
SD1	1	C	A	D	B	A	C	A
SD1	2	C	C	D	B	A	C	A
SD1	3	C	A	D	B	A	C	A
SD1	4	C	A	A	B	C	C	C
SD1	5	B	A	A	B	C	C	A
SD1	6	C	A	A	B	C	C	A
SD1	7	C	A	D	B	A	C	C
SD1	8	C	A	D	B	A	C	A
SD1	9	C	A	A	B	A	A	A
SD1	10	B	D	D	B	A	C	C
SD1	11	A	A	A	B	C	C	C
SD1	12	D	D	A	B	C	C	A
SD1	13	C	A	A	B	A	C	A
SD1	14	C	A	D	B	C	C	A
SD1	15	B	D	B	D	C	C	B
SD1	16	C	A	C	B	C	C	A
SD1	17	C	A	D	B	A	C	A
SD1	18	C	A	A	B	C	C	A
SD1	19	C	B	D	B	C	A	D
SD1	20	C	A	D	B	A	C	A
SD1	21	C	A	A	B	A	C	A
SD1	22	C	A	A	B	C	C	A
SD1	23	C	A	A	B	A	C	A
SD1	24	C	B	B	D	B	C	A
SD1	25	C	A	A	B	C	C	A
SD1	26	B	C	B	C	B	C	A
SD1	27	C	A	D	B	A	C	A
SD1	28	C	A	D	B	A	C	A
SD1	29	B	D	A	B	A	A	A
SD1	30	C	C	A	A	C	C	A

Pretest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct Answers		C	A	D	B	C	C	A
Group	Student							
SD2	1	D	A	C	B	A	C	A
SD2	2	C	A	D	B	C	C	A
SD2	3	C	A	D	B	C	C	A
SD2	4	C	D	D	D	B	A	B
SD2	5	D	C	A	B	A	C	D
SD2	6	C	C	B	B	B	C	C
SD2	7	A	B	A	B	A	C	A
SD2	8	B	C	B	D	A	B	B
SD2	9	C	C	A	B	A	C	A
SD2	10	C	B	A	B	A	C	A
SD2	11	A	C	C	B	C	C	B
SD2	12	D	C	A	B	A	C	A
SD2	13	C	C	B	A	D	C	A
SD2	14	B	D	C	A	C	D	C
SD2	15	C	A	A	B	B	C	A
SD2	16	C	A	A	B	A	C	A
SD2	17	D	C	A	B	C	C	B
SD2	18	A	B	A	B	A	C	A
SD2	19	C	B	A	C	C	A	C
SD2	20	D	A	D	C	C	C	A
SD2	21	C	C	A	B	B	C	C
SD2	22	B	C	D	C	A	A	A
SD2	23	C	A	A	B	C	C	A
SD2	24	B	B	A	B	C	A	C
SD2	25	A	B	A	B	A	C	A
SD2	26	D	C	B	D	C	A	B
SD2	27	C	A	A	B	C	C	A
SD2	28	A	A	D	B	C	C	B
SD2	29	C	B	A	B	A	A	D
SD2	30	C	A	D	B	A	C	A

Posttest answers		Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct Answers		C	A	D	B	C	C	A
Group	Student							
SD2	1	B	A	C	B	D	B	D
SD2	2	C	A	D	B	C	C	A
SD2	3	C	A	D	B	C	C	A
SD2	4	A	A	B	B	C	A	B
SD2	5	D	B	D	D	A	A	A
SD2	6	C	B	C	B	B	C	C
SD2	7	C	B	D	B	C	A	C
SD2	8	C	A	C	A	A	A	A
SD2	9	D	C	A	B	A	C	A
SD2	10	C	B	A	B	A	C	A
SD2	11	D	A	C	B	A	B	D
SD2	12	D	A	A	B	A	A	A
SD2	13	C	B	C	B	B	A	A
SD2	14	B	C	C	A	C	B	A
SD2	15	C	A	A	B	A	C	A
SD2	16	C	A	A	B	A	C	A
SD2	17	C	B	B	B	B	A	B
SD2	18	C	B	A	B	A	A	A
SD2	19	B	B	A	C	C	A	C
SD2	20	D	A	D	B	A	C	A
SD2	21	C	A	A	B	C	C	C
SD2	22	B	B	D	B	C	A	A
SD2	23	C	A	D	B	C	C	A
SD2	24	B	B	B	B	C	A	C
SD2	25	A	A	A	B	C	A	A
SD2	26	C	C	A	C	A	C	B
SD2	27	C	A	A	B	C	C	A
SD2	28	C	D	B	C	A	C	C
SD2	29	A	D	D	B	B	C	A
SD2	30	C	A	D	B	C	C	A

Attitude test

Pretest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD0	**1**	SA	A	A	SA	A	SD	A	A	A	A	D
SD0	**2**	A	SA	SA	SD	NS	SD	SA	SA	SA	SA	SA
SD0	**3**	SA	A	A	NS	A	SD	SA	D	A	SA	D
SD0	**4**	NS	A	SA	D	SA	D	SA	NS	A	A	NS
SD0	**5**	A	SD	SA	NS	A	A	A	NS	A	SA	A
SD0	**6**	A	SA	SA	D	A	SD	A	A	NS	A	A
SD0	**7**	A	A	NS	D	A	SD	SA	A	NS	A	D
SD0	**8**	A	NS	SA	SD	SA	SD	SA	NS	SA	SA	NS
SD0	**9**	D	NS	A	D	A	SD	A	A	NS	A	NS
SD0	**10**	NS	A	A	SA	A	A	A	D	NS	NS	NS
SD0	**11**	A	A	SA	A	NS	SD	A	A	NS	A	NS
SD0	**12**	A	SA	SA	SD	SA	SD	SA	A	A	SA	A
SD0	**13**	A	NS	A	A	SA	D	SA	A	NS	A	NS
SD0	**14**	A	NS	D	SD	SA	SD	SA	A	SA	A	NS
SD0	**15**	NS	A	A	D	NS	D	A	NS	D	NS	SD
SD0	**16**	D	SA	SA	SD	SA	SD	SA	SA	SA	SA	SA
SD0	**17**	SA	SA	SA	NS	A	D	SA	A	SA	SA	SA
SD0	**18**	NS	A	SA	A	A	D	SA	D	NS	SA	A
SD0	**19**	A	A	A	D	A	A	A	NS	A	A	A
SD0	**20**	A	NS	SA	D	A	A	A	D	NS	A	A
SD0	**21**	NS	A	NS	SD	A	SD	SA	D	A	A	NS
SD0	**22**	NS	SA	SA	SD	SA	SD	SA	A	NS	A	D
SD0	**23**	A	NS	A	D	A	SD	SA	D	A	SA	A
SD0	**24**	D	NS	A	SD	SA	A	SA	D	D	D	D
SD0	**25**	A	A	SA	NS	SA	D	SA	NS	D	SA	SA
SD0	**26**	SA	D	A	NS	SA	D	SA	A	NS	A	NS
SD0	**27**	A	SA	A	NS	SA	SD	SA	D	SA	SA	SA
SD0	**28**	D	SA	A	SD	A	SD	SA	A	D	A	D
SD0	**29**	A	NS	A	SA	D	D	A	D	SD	SA	NS
SD0	**30**	A	A	SA	D	A	SD	SA	D	D	A	D

Pretest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD0	**31**	SD	A	A	A	NS	SD	A	A	A	SA	NS
SD0	**32**	SD	SA	SA	SD	SA	SD	SA	SD	SA	SA	D
SD0	**33**	A	A	SA	A	A	SD	SA	NS	A	A	A
SD0	**34**	NS	SA	SA	NS	NS	SD	SA	A	NS	A	NS
SD0	**35**	SD	D	SD	A	NS	SD	SA	NS	D	SA	SD
SD0	**36**	A	NS	A	D	SA	SD	A	SA	NS	A	NS
SD0	**37**	SD	D	D	NS	SD	D	D	NS	D	D	NS
SD0	**38**	NS	A	SA	SA	SA	D	SA	SA	NS	SA	SA
SD0	**39**	A	D	A	NS	A	D	SA	A	D	A	D
SD0	**40**	A	A	SA	A	SA	D	A	A	NS	A	A
SD0	**41**	A	NS	A	NS	A	D	A	NS	A	A	A
SD0	**42**	A	SA	A	D	SA	SD	SA	NS	D	A	NS
SD0	**43**	A	NS	A	A	A	A	A	NS	A	A	A
SD0	**44**	SA	SA	A	SD	SA	SD	SA	D	SA	SA	SA
SD0	**45**	NS	NS	A	D	D	SD	A	NS	A	A	D
SD0	**46**	SD	A	SD	A	A	NS	SA	SA	SD	A	SD
SD0	**47**	D	SA	NS	SD	A	SD	D	NS	D	SA	NS
SD0	**48**	NS	A	SD	SD	SD	A	SD	A	A	SD	A
SD0	**49**	NS	SA	SA	D	A	D	SD	NS	D	SD	D
SD0	**50**	SA	A	A	D	SA	SD	SA	SA	A	SA	A
SD0	**51**	A	SA	A	D	A	SA	SA	SA	A	SA	NS
SD0	**52**	NS	A	A	NS	A	A	A	SA	NS	SA	SA
SD0	**53**	D	A	A	SA	A	A	A	A	NS	NS	D
SD0	**54**	NS	D	NS	SD	A	SD	SA	A	A	A	D
SD0	**55**	A	A	SA	NS	A	D	A	D	D	D	D
SD0	**56**	NS	SA	SA	SD	SA	SA	SD	SD	SD	SA	SA
SD0	**57**	A	A	SA	SD	A	SD	A	NS	NS	SA	SA
SD0	**58**	NS	SA	SA	SD	SD	D	A	SD	NS	A	NS
SD0	**59**	A	A	NS	D	A	D	A	NS	NS	A	A
SD0	**60**	A	NS	A	SD	A	D	A	SA	NS	A	A

Posttest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD0	**1**	A	SA	SA	A	SA	D	SA	A	A	A	NS
SD0	**2**	A	SA	NS	SD	A	SD	SA	A	A	SA	NS
SD0	**3**	SA	SA	SA	NS	A	SD	SA	NS	NS	SA	NS
SD0	**4**	NS	A	SA	SD	SA	D	SA	NS	A	A	NS
SD0	**5**	A	D	SA	NS	SA	D	A	NS	A	SA	A
SD0	**6**	A	A	SA	A	A	D	A	D	A	A	A
SD0	**7**	A	A	A	SD	A	SD	SA	A	NS	A	NS
SD0	**8**	SA	A	SA	SD	A	SD	A	A	A	SA	NS
SD0	**9**	D	A	NS	D	A	D	A	A	NS	A	NS
SD0	**10**	A	A	NS	SA	A	A	A	A	NS	A	NS
SD0	**11**	NS	A	A	D	A	D	A	A	NS	NS	A
SD0	**12**	A	SA	SA	SD	SA	SD	A	A	A	SA	A
SD0	**13**	A	A	A	NS	A	NS	A	A	NS	A	A
SD0	**14**	A	NS	A	D	A	SD	SA	A	SA	A	A
SD0	**15**	NS	D	A	NS	D	D	NS	A	NS	A	NS
SD0	**16**	D	SA	SA	SD	SA	SD	SA	SA	SA	SA	SA
SD0	**17**	SA	SA	SA	SA	A	NS	SA	A	SA	SA	SA
SD0	**18**	A	A	SA	A	A	D	A	NS	NS	SA	NS
SD0	**19**	A	A	A	NS	A	A	A	A	A	A	A
SD0	**20**	SA	D	A	A	A	A	A	A	NS	SA	NS
SD0	**21**	SA	SA	A	SD	SA	SD	SA	SA	A	A	SA
SD0	**22**	A	SA	SA	SD	A	SD	SA	A	NS	NS	NS
SD0	**23**	A	A	A	D	A	D	SA	D	A	SA	A
SD0	**24**	A	SD	SA	SA	SD	SA	SD	SD	D	D	NS
SD0	**25**	SA	A	A	SD	SA	SD	A	A	A	SA	SA
SD0	**26**	SA	NS	A	D	SA	D	SA	NS	NS	A	NS
SD0	**27**	SA	SA	A	SD	SA	SD	SA	NS	SA	SA	A
SD0	**28**	A	SA	A	D	A	SD	SA	A	D	A	NS
SD0	**29**	A	A	A	D	A	D	A	NS	SD	SA	NS
SD0	**30**	NS	SA	SA	D	A	D	A	D	A	A	A

Posttest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD0	**31**	D	SD	D	NS	D	SD	D	D	NS	A	NS
SD0	**32**	A	SA	SA	SD	SA	SD	SA	SD	SA	SA	SD
SD0	**33**	A	SA	SA	NS	A	SD	SA	D	SA	SA	A
SD0	**34**	NS	SA	SA	SD	SA	SD	SA	A	NS	A	NS
SD0	**35**	D	D	SD	A	D	D	SA	D	D	SA	D
SD0	**36**	A	A	A	SA	SA	SD	A	D	D	A	NS
SD0	**37**	SD	D	D	D	D	D	D	A	D	D	D
SD0	**38**	NS	SA	SA	SD	SA	SD	SA	A	SA	SA	SA
SD0	**39**	A	A	A	D	A	D	SA	NS	NS	A	NS
SD0	**40**	NS	A	A	NS	A	D	SA	SA	SA	SA	SA
SD0	**41**	NS	A	NS	NS	A	NS	SA	D	A	SA	NS
SD0	**42**	A	A	NS	D	SA	SD	SA	D	D	NS	D
SD0	**43**	SD	SA	SD	A	A	D	A	NS	NS	A	NS
SD0	**44**	SA	SA	SA	SD	SA	SD	SA	D	SA	SA	SA
SD0	**45**	NS	NS	A	D	A	D	NS	D	A	A	D
SD0	**46**	D	A	D	D	A	D	SA	NS	NS	A	NS
SD0	**47**	NS	SA	NS	SD	A	SD	A	NS	D	SA	D
SD0	**48**	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	NS
SD0	**49**	SD	A	SD	NS	SD	NS	SD	NS	SD	SA	NS
SD0	**50**	SA	SA	A	SD	SA	SD	SA	SA	NS	SA	NS
SD0	**51**	A	SA	A	SD	A	SA	SA	SA	A	SA	NS
SD0	**52**	A	NS	NS	A	SA	SA	A	NS	A	SA	SA
SD0	**53**	A	SA	NS	SA	SA	A	A	NS	D	D	D
SD0	**54**	D	D	NS	SD	A	SD	NS	NS	D	SA	SD
SD0	**55**	NS	A	SA	SD	NS	SD	SA	SD	SD	SD	SD
SD0	**56**	D	A	NS	A	SA	SD	D	SD	NS	NS	A
SD0	**57**	A	A	A	D	A	SD	A	A	A	A	A
SD0	**58**	NS	A	NS	NS	A	NS	A	D	A	SA	NS
SD0	**59**	A	A	A	D	A	D	A	NS	NS	A	NS
SD0	**60**	A	NS	A	A	NS	A	NS	A	SA	A	NS

Pretest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD1	**1**	NS	A	SA	D	NS	A	SA	A	D	A	D
SD1	**2**	D	D	NS	A	A	A	SA	A	NS	A	A
SD1	**3**	NS	A	A	D	NS	D	SA	A	A	SA	A
SD1	**4**	NS	NS	A	NS	SA	SD	SA	A	A	SA	SD
SD1	**5**	SA	SA	NS	SD	A	D	NS	D	SD	A	NS
SD1	**6**	NS	A	SA	NS	SA	SA	SA	SA	SD	NS	SD
SD1	**7**	SA	A	A	SA	A	SD	A	D	D	SA	NS
SD1	**8**	A	A	A	A	SA	SD	A	A	A	SA	A
SD1	**9**	NS	SA	SA	SA	A	SD	A	D	NS	A	SA
SD1	**10**	A	NS	A	NS	SA	SD	SA	NS	A	SA	A
SD1	**11**	NS	NS	A	A	A	SD	SA	A	NS	A	D
SD1	**12**	D	A	A	NS	A	D	A	D	D	A	A
SD1	**13**	A	NS	SA	SD	SA	SD	SA	SA	SA	SA	A
SD1	**14**	A	A	D	A	A	SD	D	D	A	A	D
SD1	**15**	A	A	NS	NS	D	SD	NS	A	NS	SA	SA
SD1	**16**	D	SA	SA	SA	A	SD	SA	A	SD	SD	SD
SD1	**17**	A	NS	A	D	A	NS	A	D	NS	A	A
SD1	**18**	NS	NS	A	NS	SA	SD	SA	A	NS	SA	NS
SD1	**19**	NS	A	A	D	A	D	A	A	A	A	NS
SD1	**20**	A	NS	SA	D	A	SD	SA	D	A	SA	A
SD1	**21**	A	SA	SD	D	A	D	A	D	SD	SD	SD
SD1	**22**	A	NS	A	NS	SA	SD	SA	NS	A	SA	NS
SD1	**23**	A	SA	SA	A	SA	D	SA	NS	SA	SA	SA
SD1	**24**	SA	A	SA	NS	A	A	A	A	A	A	SD
SD1	**25**	D	NS	NS	A	NS	NS	A	NS	A	A	NS
SD1	**26**	A	A	A	D	A	SD	SA	A	A	SA	A
SD1	**27**	NS	A	NS	A	SA	SD	A	A	D	A	NS
SD1	**28**	NS	NS	A	NS	SA	SD	A	NS	D	D	A
SD1	**29**	D	D	A	NS	A	D	A	NS	A	A	A
SD1	**30**	SA	A	A	SD	A	SA	SA	A	A	A	A

Posttest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD1	**1**	A	A	SA	A	NS	SA	A	A	A	SA	A
SD1	**2**	D	D	NS	A	A	NS	A	A	NS	A	NS
SD1	**3**	NS	A	A	SD	D	SD	SA	NS	A	SA	A
SD1	**4**	D	D	A	D	SA	SD	SA	A	NS	SA	NS
SD1	**5**	SA	SA	A	SD	A	SD	A	NS	SD	A	NS
SD1	**6**	NS	SA	A	SD	SA	SD	SA	SA	NS	SA	NS
SD1	**7**	SA	A	A	D	SA	SD	A	A	NS	SA	D
SD1	**8**	A	SA	A	A	SA	SD	A	D	A	SA	NS
SD1	**9**	A	SA	SA	D	A	SD	A	NS	A	A	SA
SD1	**10**	A	A	SA	D	SA	SD	SA	A	A	SA	A
SD1	**11**	NS	D	NS	A	A	SD	A	NS	A	A	NS
SD1	**12**	A	A	A	SD	A	SD	SA	A	A	A	A
SD1	**13**	NS	SA	NS	SD	SA	SD	SA	A	NS	A	NS
SD1	**14**	A	A	SD	SD	A	A	A	A	A	A	D
SD1	**15**	SA	A	A	A	NS	SD	A	A	SA	SA	A
SD1	**16**	A	A	A	SA	SA	A	SA	A	D	A	A
SD1	**17**	A	A	A	A	A	D	A	A	A	A	A
SD1	**18**	NS	NS	SA	D	SA	SD	SA	A	NS	SA	NS
SD1	**19**	NS	SA	A	D	SA	D	SA	SD	A	SA	NS
SD1	**20**	A	A	A	A	A	D	A	A	A	A	NS
SD1	**21**	A	SA	NS	SD	A	D	A	NS	SD	A	SD
SD1	**22**	A	NS	SA	SD	SA	SD	SA	D	NS	SA	NS
SD1	**23**	A	SA	SA	A	SA	SD	SA	A	SA	SA	SA
SD1	**24**	A	A	A	NS	SA	A	SA	NS	A	A	NS
SD1	**25**	NS	NS	NS	D	NS	D	A	NS	A	A	NS
SD1	**26**	A	A	A	D	SA	D	SA	SD	A	SA	NS
SD1	**27**	A	A	A	A	A	D	A	A	A	A	NS
SD1	**28**	SD	NS	A	NS	SA	SD	A	D	A	SA	NS
SD1	**29**	NS	NS	A	D	A	A	A	A	D	A	A
SD1	**30**	SA	SA	A	SD	A	D	SA	NS	A	A	A

Pretest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD2	**1**	A	NS	D	SD	NS	NS	SA	SA	NS	A	NS
SD2	**2**	A	NS	SA	SD	SA	SD	A	A	A	SA	NS
SD2	**3**	A	A	SA	NS	A	D	A	NS	A	SA	NS
SD2	**4**	SD	SD	SD	NS	SD	SA	SA	A	SA	NS	SD
SD2	**5**	A	NS	A	SA	NS	SD	SA	A	D	A	D
SD2	**6**	A	A	A	A	A	D	SA	NS	A	SA	A
SD2	**7**	SA	NS	SA	NS	SA	SD	SA	D	NS	SA	SA
SD2	**8**	SD	D	NS	D	SA	SD	A	D	NS	SA	A
SD2	**9**	A	A	NS	NS	A	D	A	NS	NS	NS	NS
SD2	**10**	NS	A	A	SA	A	SD	A	SA	SD	A	NS
SD2	**11**	A	NS	NS	SD	A	NS	NS	NS	D	A	SD
SD2	**12**	NS	NS	A	SD	A	SD	A	NS	NS	SA	NS
SD2	**13**	NS	NS	A	NS	SA	D	A	NS	A	SA	SA
SD2	**14**	A	A	D	D	NS	SD	D	NS	A	NS	D
SD2	**15**	A	SD	SD	NS	A	SA	SD	NS	A	A	SD
SD2	**16**	A	NS	A	D	A	SD	SA	D	A	SA	A
SD2	**17**	A	NS	SA	A	A	D	SA	A	A	A	A
SD2	**18**	A	NS	A	A	NS	D	A	A	D	A	D
SD2	**19**	NS	A	A	SA	SA	NS	SA	A	A	SA	SA
SD2	**20**	A	A	NS	D	A	SD	A	NS	A	A	A
SD2	**21**	A	NS	NS	D	D	SD	A	D	NS	A	NS
SD2	**22**	NS	NS	NS	NS	NS	NS	A	D	A	D	NS
SD2	**23**	A	NS	A	A	A	D	A	D	A	SA	A
SD2	**24**	SA	SA	A	A	SA	D	SA	A	NS	A	A
SD2	**25**	SA	SA	SA	SD	A	SD	SA	NS	A	SA	SA
SD2	**26**	NS	A	SA	SD	SA	SA	SA	NS	D	SA	SD
SD2	**27**	A	NS	SA	D	A	D	SA	NS	SA	SA	NS
SD2	**28**	A	NS	SA	SD	A	SD	SA	A	A	A	D
SD2	**29**	NS	SA	SA	A	A	A	SA	D	NS	A	A
SD2	**30**	NS	SA	NS	A	A	A	A	NS	D	SA	NS

Posttest answers												
Group	**Student**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SD2	**1**	SA	A	A	D	A	NS	A	NS	SA	A	A
SD2	**2**	A	A	SA	A	SA	SD	SA	A	A	SA	NS
SD2	**3**	NS	A	SA	NS	SA	D	SA	NS	A	SA	A
SD2	**4**	D	A	SA	NS	SA	SA	SA	SA	SA	SA	SA
SD2	**5**	SA	D	A	A	A	SD	A	A	D	SA	NS
SD2	**6**	A	SA	SA	NS	A	SD	SA	A	NS	SA	NS
SD2	**7**	NS	A	SA	SD	A	D	SA	SD	A	SA	NS
SD2	**8**	A	SA	A	NS	A	D	A	D	NS	A	A
SD2	**9**	A	A	NS	NS	NS	D	A	NS	NS	A	D
SD2	**10**	D	SA	SA	A	SA	SD	SA	SA	NS	SA	SA
SD2	**11**	A	D	NS	A	NS	D	D	NS	NS	NS	NS
SD2	**12**	SA	SD	NS	SD	A	SD	A	A	NS	SA	NS
SD2	**13**	NS	A	NS	NS	A	NS	NS	NS	NS	NS	NS
SD2	**14**	SD	D	SD	NS	D	D	A	D	D	NS	SD
SD2	**15**	NS	SA	A	NS	NS	SD	SA	SA	NS	NS	A
SD2	**16**	NS	A	A	A	A	D	A	D	D	A	A
SD2	**17**	A	A	NS	NS	NS	D	A	NS	NS	A	NS
SD2	**18**	NS	A	SA	A	NS	D	SA	A	SD	SA	NS
SD2	**19**	A	A	SA	NS	A	SD	A	SA	NS	SA	A
SD2	**20**	A	A	A	D	A	D	A	NS	A	A	A
SD2	**21**	NS	A	A	D	NS	D	A	D	NS	A	NS
SD2	**22**	A	A	A	D	A	D	A	NS	A	A	A
SD2	**23**	A	A	SA	NS	SA	D	SA	NS	A	SA	NS
SD2	**24**	A	A	A	D	A	D	A	D	A	A	SA
SD2	**25**	A	NS	A	NS	SA	A	SA	A	SA	SA	NS
SD2	**26**	SA	A	NS	NS	NS	D	NS	D	SA	SA	A
SD2	**27**	A	A	A	D	A	D	SA	A	A	A	A
SD2	**28**	D	A	A	NS	SA	SD	D	D	SA	NS	A
SD2	**29**	NS	A	D	A	NS	SD	A	NS	A	SA	NS
SD2	**30**	NS	A	NS	NS	D	A	A	A	NS	SA	NS