THE ROLE OF MATHEMATICS IN POLITICS AS AN ISSUE FOR MATHEMATICS TEACHING

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INTRODUCTION

In May 2007 the first author of this article arrived from Mexico to begin his doctoral studies at Roskilde University in Denmark under the supervision of the second author. Coming as an outsider to Roskilde University, there were many glaring particularities of this University such as: the project based study programmes in mathematics and science, the focus on mathematical modelling and the critical perspective on modelling, and the approach to research in mathematics education. Therefore, it was natural to take inspiration from the Roskilde experiences with teaching mathematical modelling, and from Danish research related to the teaching and learning of modelling, in the design of one of the on-line in-service courses developed as part of his PhD project. This paper is a spin off from this work. Our focus is on the analyses of some examples of mathematical models used in the Mexican society of today, and we seek to justify why and illustrate how such examples can be included in mathematics teaching and in teacher education.

THE DANISH FOCUS ON MODELLING AND CRITICAL MATHEMATICS EDUCATION

At Roskilde University (founded in 1972) already from 1975 the regulation for mathematics teacher education for upper secondary level included as one of its main aims that the teachers should be able to teach mathematical modelling to students in such a way that the role and function of mathematics in society would be demystified (Roskilde University, 1975, p.1). Mogens Niss, who was the main architect behind the programme, explains in Niss (1977) how this programme should be seen as a cure against what he describes as the crisis of mathematics instruction. A crisis which according to Niss aroused because of an imbalance between, on the one hand, the societal developments towards a high technological society with a need for mathematical competency in the wide population as well as a quest for critical citizenship in relation to the use of mathematics in society; and on the other hand an abstract and isolated mathematics instruction – especially at upper secondary level – oriented towards a mathematical elite and without connections to the use of mathematics in society. In Denmark a few years later this

discussion together with other developments actually led to the inclusion of models and applications in the upper secondary mathematics curriculum. Facilitated by a Danish research initiative called Mathematics education and democracy (Nissen, 1993), this period also marked the beginning of a strong trend in Danish mathematics education research focusing on the role and function of mathematics in society. The overall objective was to understand how mathematics teaching can contribute to the development of a democratic society (Niss, 1994, p. 376). Mogens Niss has followed this path in some of his research (Blum & Niss, 1991; Niss, 1994 and 1996) and another internationally well-known Danish professor, Ole Skovsmose, has focused his research on the role and function of mathematics in society and on the related issue of investigating the conditions – actual and possible – for a critical mathematics education (Skovsmose, 1994, 2000 and 2004; Alrø & Skovsmose, 1998).

In this paper we describe some of the ideas and concepts developed by Mogens Niss and Ole Skovsmose and others, and illustrate with some examples of the current use of mathematics in politics in Mexico, how their theoretical ideas can be used to analyse cases of societal use of mathematical models and how they can be transformed into teaching.

THE MEXICAN SITUATION

The examples that we will present in this paper are taken from the Mexican socio-political context. Mexico is a developing country trying to establish a democratic, just and inclusive society. The Mexican educational institutions play a determining role in the establishment of such kind of society. These institutions should prepare the future citizens to actively participate in the decision-making that affects and defines the social reality of Mexico.

In particular, the mathematical education that is provided in the Mexican educational institutions should pay special attention to the socio-political uses of mathematics. There is evidence showing that mathematics plays an important role in shaping the social reality of Mexico. An example of this is the "marginalization index" (see Sánchez 2009 and Sánchez 2010), that is a measure based on a mathematical model, used by the Mexican government to define the municipalities in Mexico that are in need of resources to promote social development (building hospitals, schools, etc.). However, although mathematics plays an important role in shaping the social reality, the mathematics education that is provided in Mexico does not seem to acknowledge this role.

For instance, in the article Sánchez (2007), the perception of the role of mathematics within the Mexican educational system is discussed. In particular, it was intended to provide a modest answer to the question "what is the justification for teaching mathematics in Mexico?". This question is embedded in the more general problematique concerning the problem of justification in mathematics education (Niss, 1996, Ernest, 1998). The above question was addressed by looking into the official records of the Mexican Ministry of Public Education. One of the documents that to some extent provide an answer to the previous question is the so-called "foundations of the curriculum for the reform of the lower secondary education[1]". The document states:

> "[Mathematics are useful] to cope with fractions, to plot functions, to calculate angles, probabilities and perimeters. But also to encourage abstraction in order to facilitate reasoning, develop the argumentation, and introducing to the proof" (Secretaría de Educación Pública, 2006, p. 9, our translation).

Other official documents from the Ministry of Education that were found in this survey, portray mathematics as a tool that helps students to understand the physical phenomena around them (see Sánchez, 2007). Thus, the official justification for teaching mathematics is to provide students with mathematical understanding, but it is not discussed how the students' understanding of mathematics is relevant to the Mexican society in general. Moreover, mathematics is presented to the students as a topic that is important to study and to understand because it will help them to learn more mathematics. At best, mathematics is presented to the students as a topic that will help them to understand other school topics as physics and chemistry. Mathematics is not presented to the students as a tool that can be used for prescribing our political and economic reality[2]. We believe that this perception of the role of mathematics is not specific to the educational institutions. It is common to find mathematics teachers who are not aware of the connections between mathematics and the configuration of social reality, and therefore do not included them in their teaching.

This lack of connections between mathematics and society (as presented in the Mexican education system) has consequences. For example, there is a risk of making students to

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[1] This document makes reference to the national reform of the lower secondary education in Mexico that started on 2006 and remains in force.

[2] Here we refer to the formatting power of mathematics. For a discussion on such concept see Niss (1983) and Skovsmose & Yasukawa (2004).

interpret mathematics as a school subject that exists and is only relevant within the school. This situation tends to produce a poor image of mathematics in the students. Another consequence is that the school curriculum does not encourage teachers to relate mathematics to other subjects. This also contributes to create a restricted image of mathematics in the students.

If we share the idea presented in Skovsmose (2000) about the need for educating "our youth, our citizens, so that they begin to understand and critique the formatting power of mathematics in society", then more work is needed in order to change the general perception about the role and nature of mathematics. Part of our contribution as mathematics educators to support such a change may consist of designing mathematical activities for the classroom, aiming at explicitly illustrating and analysing such formatting power. We think that, in order to prepare students to identify and evaluate socio-political applications of mathematics, it is essential to show them and discuss with them real instances of such applications. We claim that such activities could be based on authentic applications of mathematics within the political systems of our societies. In the next section we present the arguments for considering the use of mathematics in politics as a useful resource for the mathematics classroom.

WHY TO INCLUDE THE USE OF MATHEMATICS IN POLITICS?

Our arguments for advocating the use of mathematics in politics as a resource for mathematics teaching are mainly two. Firstly, to show how mathematics is applied within the political context can have an important motivational value. There is research indicating that the study of authentic and contemporary applications of mathematics can arouse a great interest among students. An example of this can be found in the empirical research reported in Jankvist (2009), where modern histories of applications of mathematics are used to motivate and change students' conceptions about mathematics. In this regard the author states: "The fact that the history is a newer and fairly recent history of mathematics seems to make it easier for the students to relate […] Concerning the history of modern applications of mathematics some students may find it more interesting to work with such a history, and possibly even more so if they recognise elements from everyday life" (Jankvist, 2009, p. 11).

Although this study refers to the use of history of mathematics in the classroom, it is a case that can be used as an analogy to illustrate the motivational value that the use of

mathematics in contemporary politics could have for the students. Such examples might be easy to relate to aspects of students' daily life. However, we have other reasons to believe that the use of mathematics in politics would be interesting and motivating for mathematics students and teachers.

When the video "government and mathematics" was published on *YouTube* (see Sánchez, 2010), several comments from "ordinary" citizens were received. Many of them thought that the topic addressed in the video was interesting and they even recommended it to other people. An example of this is the following comment posted on the social network Twitter (see figure 1), which can be literally translated as: "Interesting video http://youtu.be/I1s2exbD5T0?a how politicians govern us with limited mathematical models (via @dontriana)". The author of the post is promoting the video among his contacts in the social network, but he in turn received the recommendation on the video through another user of the network. We consider this process as a manifestation of the interest that certain people had in the content of the video.

Figure 1. Tweet retrieved from http://twitter.com/loronegro/status/10692832802 that expresses interest in the content of the video Sánchez (2010). Note that such video was previously recommended by the user @dontriana

We think that this video was interesting for the viewers because its content can be easily related to the social reality experienced in Mexico. Thus, we argue that a mathematics teaching that is detached from the social reality experienced by a country can appear demotivating for the students. Similarly, a mathematics teaching that has strong links with the social reality may be more attractive and motivating for the mathematics students. Maybe this is true in particular for developing countries.

A second argument for considering the application of mathematics in politics as a resource for mathematics teaching is that, politics is a context that can be useful to explicitly illustrate the formatting power of mathematics. In other words, it is a context that can help us to make evident how mathematics can be used to legitimise and justify political decisions that directly and significantly affect the social dynamics of some communities and the lives of their inhabitants.

It is important to explicitly illustrate and study these kinds of applications of mathematics, because they can serve to nourish a sense of civic awareness in the students and teachers towards the use of mathematics by politicians and government institutions. We think that such kind of activities would contribute to prepare students and teachers to identify, evaluate and respond critically to the consequences of such use of mathematics. Furthermore, we believe that the discussion of such mathematical applications can enrich students' perceptions about the nature and role of mathematics.

Nevertheless, we are aware of the fact that locating instances of applications of mathematics in politics is not enough for using them into the classroom. Teachers need to have some sort of guiding regarding the aspects they should focus on when discussing this kind of applications of mathematics in the classroom. We claim that mathematics education research can guide us about the aspects that could be the focus of attention when using the applications of mathematics in politics as an aid for the development of mathematics teaching.

HOW TO INTEGRATE MATHEMATICS IN POLITICS IN MATHEMATICS TEACHING?

Whenever mathematics is used in politics to describe, predict or even prescribe reality there is always some type of mathematical model involved (Niss, 1994, p. 369). Even the most simply statistics presuppose assumptions and choices about what to count and how to represent the results. Mathematical models used in politics or in societal administration vary a lot in function, complexity and in mathematical content and representation. Therefore, there is a need for theoretical ideas that can guide and structure the analysis of the use mathematics in politics and society, but also, we are in need of didactical ideas that can support the transposition of such analyses into mathematics teaching practices. In this section we present some examples of such ideas already tried out in practices of mathematics teaching in a Danish context. We do not claim by any means to cover the area

of mathematics education research relevant for including the use of mathematics in politics in the teaching of mathematics.

Despite the great variation of mathematical models used in politics, they can all be discussed according to their role in the context or contexts where they are being applied. One very general categorisation of models use in politics is the division in descriptive, predictive and prescriptive models (see for instant Davis & Hersh, 1986, p. 120).

A mathematical model is descriptive when it is used to represent and communicate the current state of a situation. A predictive mathematical model is the one that is used to anticipate or predict what the future state of a situation or problem will be based on a model of the system in the current state. Predictive use of mathematical models is common in relation to societal decision making where it is important to be able to predict the effects of possible political regulations in often very complex societal systems. Models in economical planning, traffic planning, environmental planning and planning of energy supply and production are all examples for mathematical models that are used by the political or administrative systems to predict the possible effects of changes or regulations in these systems. Mathematical models are also used in society to define systems that actually shape the political or social reality in which we are living. Such use of mathematical models is characterised as prescriptive.

> [...] there are plentiful examples of recent and recently reinstated prescriptive mathematizations: exam grades, IQ's, life insurance, telephone switching systems, credit cards, zip codes, proportional representing voting…. We have prescribed these systems, often for reasons known only to a few, they regulate and alter our lives and characterize our civilization. They create a description before the pattern itself exits. (Davis & Hersh, 1986, p.120-121)

Of course, not all the examples mentioned in the quote belong to the domain of politics and many of them are integrated in technological systems. However, many of these mathematised systems – which are, in fact mathematical models – have political and societal impacts. Just to make sure it is the functions of models that are characterised here – not the models themselves. The same mathematical model can have different functions in different contexts.

If we want to analyse and discuss applications of mathematics in politics with students, one possible first approach is to let the students experience and discuss concrete examples of mathematical models used in society in relation to these three categorises (descriptive,

predictive or prescriptive). In our experiences it is possible and motivating for students from secondary level and above as well as for mathematics teachers to work with these categorises and even find examples within each category themselves. The students do not need to understand completely the mathematical structure of the models in order to work with them in relation to this categorisation. The function that a model plays can be analysed through the context in which it is used, and therefore such activity can be organised at different educational levels. Even though this sort of discussions is somehow general and not strongly related to the internal mathematical structure of the model, it can be very useful for enriching the students' image of mathematics and its applications. For most students and even for some mathematics teacher it appear as a surprise for them that mathematical models are widely used in politics and in relation to societal issues, and the models can play different roles and even sometimes prescribe parts of the political and economic reality we are living in.

Skovsmose has analysed deeply the roles and functions played by mathematical models in society both from a philosophical point of view and through analyses of concrete cases of societal applications of mathematical models (see for instance Skovsmose (1990, 1994) and Skovsmose & Yasukawa (2004)). In this research it is established that mathematics through modelling and models exerts a formatting power in modern societies. Furthermore, this formatting power of mathematics constitutes a major challenge for mathematics education research and for the practice of mathematics teaching. In order for mathematics teaching to contribute to general education in favour for democratic societal developments, mathematics teaching needs to take role of mathematics in society and politics seriously.

During a Danish research initiative in the years 1998-2004 a number of research and developmental projects with experimental teaching were carried out in order to investigate how this challenge can be meet in mathematics teaching already at lower secondary level (Skovsmose & Blomhøj, 2003 and 2006). Findings from analyses of authentic applications of mathematical models were used to structure courses of lessons which aim at including a political dimension. One example of such finding, which is relevant for mathematics teacher education, is the following four types of general side-effects in relation to the use for mathematical models in a technical or societal investigation or decision making process (Skovsmose, 1990, p 128-133). In our translation and rephrasing these are:

(1) A reformulation of the problem in hand in order for it to be suitable for analysis by means of a mathematical model.

(2) A delimitation of the group of people engaging in the public discussion about the problem in hand to those who are able to understand the model and its role in the decision process – Ole Skovsmose calls this group the base of critique.

(3) A shift in the discourse away from the political and societal reality towards quantitative claims and arguments related to the model – the model becomes the object for the discourse.

(4) A delimitation of the possible solutions or the alternative political actions taken under consideration to those that can be evaluated in the model.

The point here is of course not that the use of mathematical models should be avoided as a tool in political and societal decision making because of the side-effects. Mathematical modelling is an indispensable part of a modern technological society. The point is that the use of mathematical models in society is neither good nor bad nor neutral by any means. Therefore, it is important that mathematics teaching in general education contribute to the development of a critical awareness of and a competence to analyse the possible effects of the use of a mathematical model in a decision processes. Even though, that the detection of such effects and the related reflections do not need to be closely related to the mathematical structure of the model involved, mathematical modelling competency is a prerequisite for conducting such analyses. Therefore, it is mathematics as a subject that has to address the educational challenge related to the formatting power of mathematical models in society, and therefore these issues much be included in mathematics teacher education - nobody else will do it.

General discussions about types of mathematical models and their functions in politics could serve to nurture and broaden teachers' and students' images of mathematics and its applications. However, in mathematics curricula, at say secondary level, it might be difficult to find space for such extra mathematical aspects. Analyses of the inner mathematical structure of an authentic model might be a way of approaching the study of mathematical applications in politics, which is easier to integrate in the practice of mathematics teaching. Such analyses can be structured according a general model of a mathematical modelling process (see figure 2). A concrete case of modelling can be analysed with respect to one or more of the six sub-processes included in a modelling

process, namely: problem formulation, systematization, mathematization, mathematical analysis, interpretation/evaluation, and validation. For example, we can discuss with the students the assumptions underlying a model and what are their implications. Such kind of discussion refers to the systematization sub-process. It is also possible to discuss the role of the variables and parameters within a mathematical model: What do they represent?, How are the values of the parameters estimated?, and What are their effects on the models results? This is one way of addressing the sub-process of mathematical analysis. It is also important to discuss with students the sub-process of interpretation/validation. Questions like: On what ground can the model be validated?, Is it possible to obtain an alternative interpretation of the modelled situation? or Does the model adequately capture the situation in hand? These questions are relevant within the discussion of the interpretation/validation sub-process.

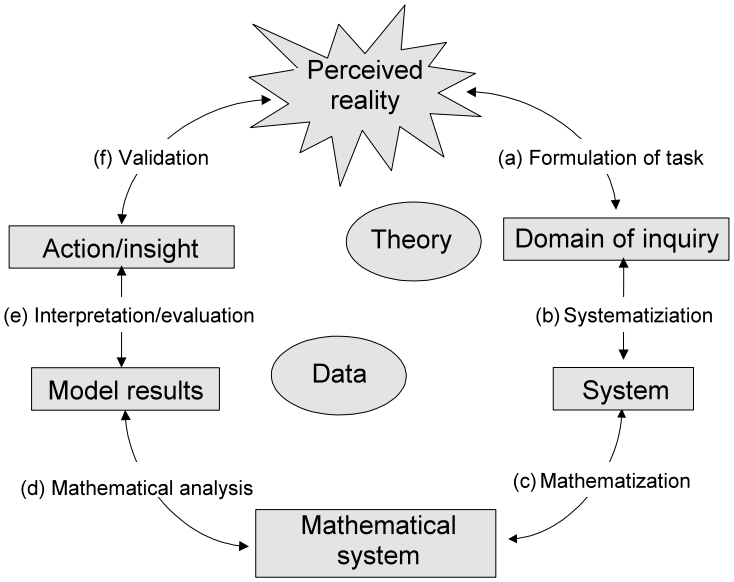

Figure 2. A model of a mathematical modelling process. The modelling process is interpreted as being composed of six sub-processes (Blomhøj & Jensen, 2006, p.48).

The point here is that the students through their work with a concrete case get acquainted with a model of a modelling cycle as a tool for analysing the process behind models used in relation to particular political decisions. Examples hereof from the project work at Roskilde University are found in Blomhøj & Kjeldsen (2010). Such approach is of course relevant only for students that have previous experiences with the modelling cycle as a tool for supporting their own modelling activities.

Last but not least, students' work with authentic societal and political problems can serve as a motivation for and as a means for the learning of important mathematical concepts and methods. As illustrated, in the examples which follow, it is possible for students already form lower secondary level to activate their mathematical competencies in relation to societal and political issues.

SOME DIFFICULTIES IN STUDYING THE USE OF MATHEMATICS IN POLITICS

We are aware of the fact that locating instances of applications of mathematics in politics, and discuss them in the mathematics classroom, is not a straightforward task. Based on our experience we can say that there are some obstacles to this activity.

The first difficulty that we found is that the information is not easily accessible. Even though the politicians and the government institutions make use of mathematical calculations and results to present reports, make decisions and put forward arguments, the mathematical techniques and models used for carrying out these calculations and results are not always explicit or directly accessible. To locate those unrevealed mathematical tools it is necessary to perform extensive searches into the records and websites of the government/political institutions, and even make direct information requests to the government offices.

We have found that newspapers and news broadcasts are also useful resources where examples of politicians and institutions using mathematics can be found. It is useful to create an archive with articles, graphs, interviews and the like, to then select the material that could be discussed with the students. Further on we will present an example that suggests how this type of material could be used in the mathematics classroom.

Another difficulty relates to the complexity of the mathematics applied. In some cases we located mathematical models that are used by the government agencies to carry out different calculations. However, the mathematics involved in those models was too complex to be discussed with all of our students. There are at least two ways to cope with this situation:

One way is to try to reduce the complexity of the mathematical model that we want to discuss with the students. This can be achieved by focusing only on some components of the mathematical model. In fact this was the strategy that we follow when we discussed with a group of teachers the mathematical model used by the Mexican government to

locate Mexico's most marginalised municipalities. Since this was a group of teachers with a heterogeneous mathematical background (some of them were primary level teachers and others were working at the university level), it was necessary to focus only on a small part of the model. This was a procedure that made the discussion mathematically accessible to everyone. In the next section we will show the part of the model in which we focused on.

We, however, are not suggesting that the examples of applications of mathematics in politics that are mathematically complex should be always simplified or even avoided. Another possibility to address this situation is to use such examples in preparing students who will study mathematics on a higher level. We believe that the education of the future mathematicians, economists, engineers and other specialists could be enriched by analysing and discussing the advantages, limitations and consequences of applying such mathematical models in social contexts. In the next section we present some authentic examples taken mainly from the Mexican context. We think that these examples are worthy to be used in mathematics teaching.

FIRST EXAMPLE: THE MARGINALIZATION INDEX

We have referred to the marginalization index throughout this article. The marginalization index is a measure that is used by the Mexican government to determine which are Mexico's most marginalised municipalities. This measure is calculated by using a mathematical model. We discussed part of this model during an in-service course for teachers in mathematical modelling (this experience is reported in Sánchez, 2009). Our aim was to discuss this model to illustrate one of the arguments that have been provided to include mathematical modelling in the school curriculum. Here we refer to the "critical competence argument" presented in Blum & Niss (1991). The argument is based on considering mathematical modelling as a means to "enable students to 'see and judge' independently, to recognise, understand, analyse and assess representative examples of actual uses of mathematics, including (suggested) solutions to socially significant problems" (Blum & Niss, 1991, p. 43).

The mathematical model measures nine socioeconomic indicators for each municipality, however, it would be complex to discuss all of them with the teachers. Complex because the mathematics required to understand the structure of the model could be very demanding for some teachers. Therefore we decided to focus the discussion on only one

socioeconomic indicator[3]. The one aimed at indicate the percentage of the employed population with income less than or equal to twice the minimum wage. This indicator is calculated using the following formula:

$$I_{i9} = \frac{P_i^{sm\leq 2}}{P_i^0} \times 100$$

Where:

$P_i^{sm\leq 2}$ is the part of the employed population, who receives less than two minimum wages.

P_i^0 represents the total of the employed population

During our discussion with the teachers, we emphasise that this part of the model is inadequate to detect all the sources of wealth in a community. For instance, if we go through the definition of "employed population" that is used in the model, we will find that the definition considers as employed all those persons aged 12 or older who have worked at least one hour, one week before the interview is conducted[4], even when they have not received payment for their work. This definition, which is part of the model, has consequences. One consequence is for example that the model could yield a small number, which means that in the locality where the model was applied only few people earn twice the minimum wage or less. But the number does not say anything about the children below the age of twelve who are working. Said otherwise, the model is not sensible to child labour and exploitation. This is a variable that should be considered in the marginalization index, because Mexico has a large number of children who work, often

[3] The nine indicators are: Percentage of illiterate population, percentage of population without complete primary education, percentage of population without toilet or drainage, percentage of population without electricity, percentage of population without access to piped water, percentage of private homes with a level of overcrowding, percentage of population living with a floor made of soil, percentage of population in localities with fewer than 5,000 inhabitants, percentage of the employed population with income less than or equal to twice the minimum wage.

[4] The data entered in the model are collected through population censuses based on interviews with the residents of the municipalities.

without receiving any remuneration for their work[5]. Those children are of course marginalized, but the model will not detect them.

There are other sources of wealth that can be omitted by the marginalization index. In the official document where this part of the model is introduced, there is a footnote explaining that when the data are collected in order to introduce them in the model, many people, especially those with the highest income, tend to omit information about their income. In the Mexican context it is not difficult to identify municipalities where the majority of the employed inhabitants are involved in the production and commercialisation of drugs or other illegal activities. It can be expected that these people will omit information about their incomes. Thus, the above-presented component of the marginalization index could label a community as poor and therefore marginalised, when in reality it is a wealthy community, but the wealth has been produced illegally by the drug trafficking or other illegal business.

We believe that this activity contributed to the professional development of the mathematics teachers who participated in the course. Some of them discovered the role that mathematical modelling can play in government's decision making. Some teachers found that mathematics can inform decisions that affect the lives of hundreds of people, but not necessarily in a positive way. Some of them even expressed interest in bringing such kind of examples of applications of mathematics to their own classrooms.

However this kind of models can be also discussed with mathematics pupils. The marginalization index is an example of a descriptive and prescriptive model. It helps to describe the welfare level of Mexican municipalities, but also it also indicates where the resources for social development should be targeted. In addition, internal reflections can be arranged around the operation of the model, for example, what are the variables of the model? What do they represent? How do they affect the final result produced by the model? What are the assumptions that underpin the model? On the other hand, external reflections can also be encouraged. For example those addressing the consequences of the model like: What aspects of reality that the model attempts to capture are not adequately represented? What are the consequences of such limitations of the model?

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[5] One of the last studies in this respect estimates that in 2002 there were 1.1 million of boys and girls ageing between 6 and 11 working in Mexico. See Instituto Nacional de Estadística, Geografía e Informática (2004).

We claim that such discussions can help to make the students aware of the possible consequences of the application of mathematics in social contexts. Such discussions would sustain a mathematics education that promotes the application of mathematics with responsibility and ethics.

SECOND EXAMPLE: USE OF MATHEMATICS IN POLITICAL DISCOURSES

As previously mentioned, newspapers and news broadcasts are important sources of information where examples of how mathematics is used by politicians to substantiate reports and justify arguments can be obtained.

Let us take as an example the media coverage of the so-called *war on drugs*. This "war" is a campaign of prohibition initiated by the government of the United States[6]. Since its inception in the 70s, the Mexican government has supported this campaign despite the devastating effects that this fight has produced in Mexican society. Over the years the Mexican government has reported on the outcomes of this fight in Mexico. The Mexican historian Luis Astorga has pointed out that mathematical calculations have been used in a misleading way to substantiate some of these reports:

> "[T]he authorities have sometimes used misleading ratings for their statistics [...] For example, in the National Program for Drug Control 1989-1994 there is a criterion which makes equivalent one hectare of eradicated poppy to one kilo of destroyed heroin. Thus, an area which is planted with poppies and eradicated is plotted as <<destruction of opium and heroin>>, those are substances that never existed but only as a possibility or in a small proportion regarding the total represented. The graphic illusion is based on the assumption that if all conditions had been optimal for the extraction of raw materials and further processing, then what was presented would be true. The problem is that this hypothesis is not explicit and it is presented as real, creating in the naive reader the intended effect by the act of statistical illusion" (Astorga, 2005, p. 128, our translation).

Through the newspapers and the news broadcasts we have found other instances of utilization of mathematics to justify the war on drugs in Mexico. One such example is the interview with the current President of Mexico Felipe Calderón carried out by the journalist Wolf Blitzer for the American cable news channel CNN. The interview was carried out during Calderón's state visit to Washington in May 2010.

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[6] See http://en.wikipedia.org/wiki/War_on_Drugs

Felipe Calderón has been heavily criticised for his decision to deploy federal troops (policemen, soldiers, marines) in the streets of Mexico for combating drug traffickers. This strategy has generated a huge and ever-increasing number of deaths, among which hundreds of innocent civilians are estimated to be included[7]. Despite the criticism, Felipe Calderón has not changed his strategy for fighting against drug cartels.

During the interview with CNN, President Felipe Calderón was asked about the insecurity caused by the drug war in Mexico. In response, Felipe Calderón used statistical arguments to depict Mexico as a safe country. These arguments are shown in the following transcript of an excerpt from that interview:

Transcription of an interview broadcasted by the american news channel CNN in May 2010[8]
(From minute 3:20 to minute 5:21)

Journalist (J): Americans love visiting Mexico whether Cancun or other places. Why you don't look in the camera and tell Americans why travel, tourism, visiting Mexico is safe and they need not worry, because a lot of Americans right now you know they are worried.

Felipe Calderón (FC): I know but first, Mexico is a lovely country …

J: That's true

FC: …and second Mexico is a country who is passing…is having a trouble but we are fixing the trouble, we are facing the problem and we will fix it. Third, if you analyse for instance the figures, you need to put in a context this problem of crime in Mexico. The rate of homicides for 100,000 people in Mexico is 12 homicides per 100,000 people. If you analyse any other country, for instance if you prefer fly to Jamaica or Dominican Republic you need to understand that the rate of homicides there is 60 homicides per 100,000 people or Colombia is 39 or Brazil is 23 the double than Mexico.

J: So you are saying it is safer visiting – if you are tourist – Mexico than some of these other countries.

FC: According with these data yes, and even let me tell you that if you feel safer here in Washington DC, Washington DC has 31 homicides per 100,000 people which means the triple, almost the triple homicides than Mexico, according with the proportion of the

[7] The Center of Investigation and National Security of Mexico (CISEN) estimates that more than 28,000 persons have died during Felipe Calderón's term. See: http://t.co/zZAjeHt

[8] The extract of the interview has been transcribed faithfully. It may include actual grammatical errors made by the speakers. The full version of the interview is available at: http://edition.cnn.com/2010/US/05/19/mexico.president.visit/index.html

> population. And I don't want to deny that we have a problem. Yes. But we are facing that problem and we are using all the resources of the state. That problem is not focused on the places that Americans use to visit like Cancun or Vallarta or Baja or Los Cabos. Those places, some of them even are safer as vary cities… as several cities in Europe or other places, so visit Mexico you will help us and we will working for…to make Mexico a safer country in favour not only the tourist but also our own families.

These kinds of speeches can be used to organise mathematical discussions in the classroom. It is relevant for example to discuss how the rate of homicide can be classified as a descriptive model, but it is also relevant to have external reflections on the model addressing how well it captures the levels of violence experienced in Mexico. For example, since the statistical data used by Felipe Calderón correspond to the entire country, they are not adequate to represent the violence at the local level. Such statistical data hide the fact that there are cities such as Ciudad Juarez, where it is estimated that in 2009 there was a homicide rate of 133 per 100.000 inhabitants. These statistics do not indicate the high level of violence involved in the homicides. They do not reveal that many of these murders have been preceded by abductions, torture, rape and mutilation. They do no reveal who the victims of such murders are, which include children, journalists, high ranking government officials, among many others.

THIRD EXAMPLE: GRAPHICAL REPRESENTATION OF INFORMATION

The newspapers and TV news are full of graphs that are used to communicate relevant information. These graphs can be interpreted as mathematical models that represent a particular segment of reality. Therefore, students must learn that such representation of reality is not unique and therefore not neutral. There may be alternative representations that could bring into light aspects of the phenomenon represented, that the original representation may ignored or excluded.

Let us take as an example the following graph that was published in 2009 on the online version of the newspaper *New York Times* (see figure 3). This graph is used to represent the number of drug-related killings in Mexico. The graph shows a marked increase in the number of deaths at the beginning of 2007, just weeks after the federal troops were mobilised on the streets of Mexico to fight the drug gangs.

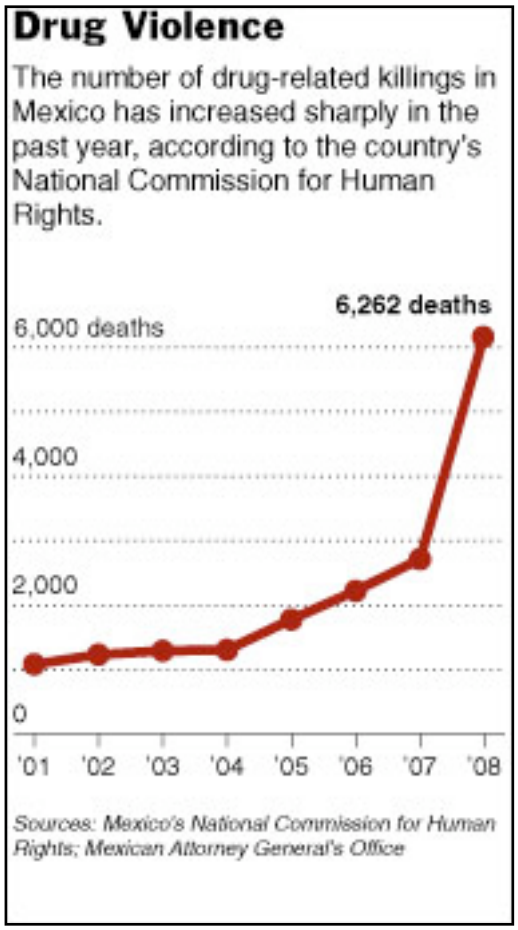

Figure 3. Graph representing the number of drug-related killings in Mexico during the period 2001–2008. This graph was published in the online version of the American newspaper *New York Times* in 2009.

This graph is suitable for organising internal reflections that promote mathematical understanding among students. For example, it is possible to discuss with the students what is the meaning that the mathematical concept of slope acquires within this context: What happens when the slope increases? What could be the meaning of a negative slope? If we take as a reference the data provided by the graph, what could be the expected number of drug-related killings in Mexico for 2010?

External reflections can be also arranged around the graphical representation. Particularly reflections related to the use that the politicians do of this type of graphs. Representatives of the Mexican government have used such kinds of graphs to legitimize the outcomes of the war on drugs. The usual argument consists on claiming that indeed there is a relationship between the moment in which the federal troops occupied the streets of Mexico and the death toll produced. However, it is claimed that the dead people are only

criminals. Again, the model is used to produce a kind of illusion that allowed politicians to allege that the "war" is producing good results.

But as previously mentioned, students should be aware that there might be other descriptive models that could show different aspects of the same phenomenon. For example if we make a zoom-in to a region of such kind of graphs, we will find information that cannot be assessed from a global perspective. An example of this is the graph shown in figure 4 that was published in 2009 in the Mexican newspaper *El Universal*. This graph shows the number of drug-related killings in Mexico during the period from August 1 through September 10, 2009. This zoom-in reveals other information, for example, that several civilians were killed, that some of the victims are police chiefs, that a single attack of a criminal gang can produce up to 18 dead people, that the deaths are mainly concentrated in five Mexican states, etc.

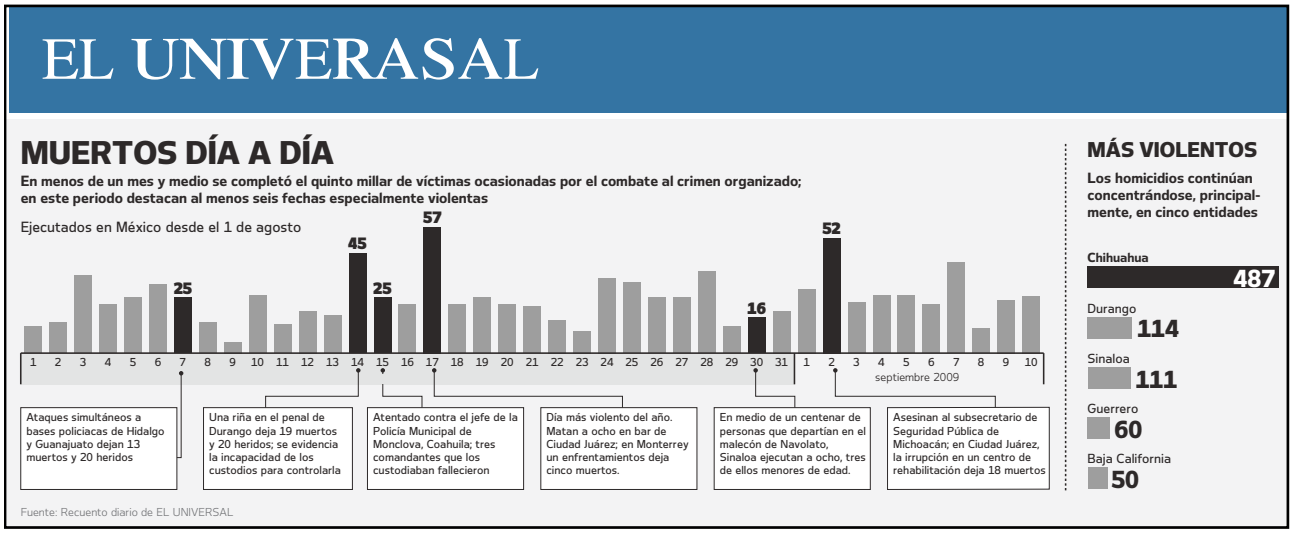

Figure 4. Graph providing a detailed account of the number of drug-related killings in Mexico during the period from August 1 through September 10, 2009. This graph was published in the online version of the Mexican newspaper *El Universal* in 2009.

The point here is that mathematics students should know that a descriptive mathematical model could focus on certain aspects of the phenomenon represented, but hide or ignore others. It is therefore relevant to allow students to make comparisons between different descriptive models representing the same phenomenon and discuss with them the strengths and limitations of each description provided by the model.

FINAL COMMENTS

Politicians and government institutions use mathematics to underpin their proposals and arguments and in decision making related to social problems. Skovsmose (1990) has warned us about some of the effects that are produced when mathematics is incorporated into the discussion of non-mathematical problems. For instance, the original problem is reformulated into a different kind of discourse (a mathematical discourse). As a consequence, the group of people who could participate in the discussion of the problem and its solution becomes smaller and it has a very specific composition. It would be integrated only by those citizens with certain mathematical knowledge, who could be able to discern and criticise the use of mathematics in the discussion.

It is our responsibility as mathematics educators to provide our students with a mathematical education which could enable them to take an active and critical participation in the society. A mathematical education that prepares them to identify and analyse the applications of mathematics in addressing social problems. We believe it is worth discussing with the students examples such as those we have shown in this article. This because they clearly and explicitly illustrate the kinds of consequences that may result of the application of mathematics in such contexts. We believe that this type of mathematical education would positively affect their education as citizens.

It is however necessary to promote these ideas in the classroom. We need more enthusiastic teachers and researchers willing to conduct experiments and empirical research reporting the type of results that this approach of mathematical education can produce.

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