Optimal number of students in the class

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Abstract

This contribution describes the model for determining the number of pupils in the class of one teacher in primary school education in context of Slovak Republic. Actually, legislation defines the minimal and maximal number of pupils in the class. The model which we created is based on economic principles. These are usually different from "politically acceptable solutions".
Our model rises up from the presumption that greater is a number of pupils in the class the parents have to study more with their children at home and complete the work of teachers at home. But greater number of pupils in the class decreases medium labor costs for teacher per pupil. The simulation permits to define different range of parameters and to compare results for different variants.

Keywords: pupils, class, number, parameters, simulation, cost function, Slovakia.

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1. Introduction

The teachers´ salary becomes a frequently mentioned topic in social discussion. Teachers request their immediate increase. Minister of education refers to their average salary greater than 1000 Euro (Folentova, 2016). Anyway it is important to realize what is the impact of education on the nation and the country – in microeconomic as well as in macroeconomic point of view. Psacharopoulos (1994) says that investment to education will be many times given back in the future from the macroeconomic point of view. Blundel, Dearden and Sianesi (2005) and Card (1999) say that the good education has even an influence the future salary of these children. Department of education in Great Britain (2011) studies the relationship between the size of the class and the quality of education. Ehrenberg et al. (2001) and Hoxby (2000) analyze the size of class and results of pupils. Consequently, based on these and many others studies Monks and Schmidt (2010) claim that there exists interdependence between the size of the class and future incomes of pupils. Winkleby, Jatulis, Frank and Fortmann (1992) go further and say that the number of pupils in the class can influence their health such as risk factors for cardiovascular diseases. Due to this analysis it is clear now that it is profitable for society to be engaged by education settings such as teachers´ salaries. But the question is how to set a system of salaries in the way that it would be optimal for the society from the socio-economic point of view.

The way for teachers how to get greater salary can lead through the increase of the number of pupils in the classes. There are some analysts who claim that the school network would reduce in case that the minimal number of pupils in the class would moderately increase. And that would permit to increase the teachers´ salaries of more than 10%. We only have to decide. Or we want to have many classes with few pupils and teachers with low salaries or less classes with teachers of better quality and better payed. The ministry proposes to increase the maximal number of pupils in classes of primary schools to 28 (till now the maximum number for the 1st class it was 22 pupils per class and 25 pupils in the 2nd – 4th class). In secondary school the maximal number of pupils in the class should increase from 28 to 30. (In Slovakia primary school is for children old from 6 to 9 years. We use to call it "the 1st grade of basic school" and lasts 4 years. Secondary school concerns so classes 5 – 9 and educates pupils old from 10 to 14 years and is called "2nd grade of basic school. Each grade has different requirements to teachers. The reader of this paper can find different terms to describe basic school organization, but all say the same.) The department of education argues that they got inspiration for maximal number of pupils in class in average plenarty in OECD countries.

The Slovak chamber of teachers (SCT) wants to keep the actual model. "We don´t agree with this action which only solves economic problem and doesn´t consider the need of quality development in schools, the individual development of child´s personality and constant increase of load of pedagogic employee" say the management board of SCT. Zuzana Zimenová, the specialist for education system from portal noveskolstvo.sk, thinks about the school network optimization question that actual school system is so much roped by requirements that school should define themselves the numbers of pupils in classes. She doesn´t consider as a good way to use a directive to prescribe it. Somewhere they have more talented mathematicians, somewhere else sportsmen or children with artistic talent. The number of pupils in the class should respect their needs and that the teachers would be able to give enough attention to each pupil.

The special pedagogue Jana Zajacová says that class should consist of about 20 pupils, and in the first class even less. And because to new rules schools have to integrate more to classes children with learning difficulties and behavioral problems, with light mental disability or socially disadvantaged – so teacher would have problem to handle more numerous class. Representatives of ZMOS (Association of towns and communities of Slovakia) adopt a cautious approach. They are aware of the fact that a daily transport of pupils from canceled "low class number schools" (schools where there are less than 9 usual classes typical for basic school – because of low number of pupils some classes with different level are joined) to other schools would require the creation of the network of school buses or the

recreation of some canceled regional transportation lines. "We suppose that by counting all cost which would be municipalities obliged to accept, we would find out that earnings would be minimal or none," notices executive vice president of the association Milan Muska.

In the USA the growth of investments from the year 1890 to 1990 from 2 to 187 billions of Dollars in constant prices (Gladwell, 2015). The financial means were mostly spent for hiring new teachers and for reducing population in classes. In the years 1970-1990 the ratio defining the number of pupils per teacher decreased from 20,5 to 15,4 and expenses for education extremely increased. There are almost 300 basic schools in Slovakia with 20 or less pupils and they are 5-6 in one class. In other schools there are sometimes even 35-40 pupils (UIPS, 2015).

2. Model

We perceive the created model as a kind of simplification of presented problem. The effectiveness of the model raises from the elimination of unimportant details permitting us to understand relevant characteristics of real economic problems. The accurate choice of parameters for model is crucial for successful composition of model.

Our approach to this problem is based on facts that some studies. Gladwell (2015) says that there is a dependence between study results and the size of the class. We present it by our model on figure 1.
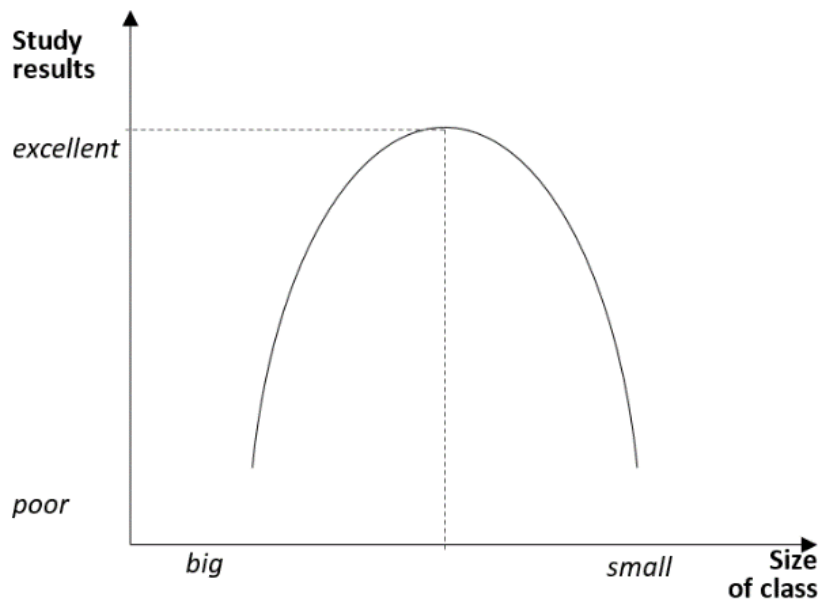

Figure 1. Model of dependence between study results and the size of class.

Our model for finding optimal number of pupils in classes is based on minimization of costs spent for education of pupil. The function, minimum of which we are going to find, consists of two cost functions. The first one is the average costs for education of pupil at school. The second one is the average costs for education of pupil at home (tutorial classes) that he or she (s/he) reaches desired results. The fig.2 presents steps by which we were progressing in testing our presumptions considering relation between size of class and study results.
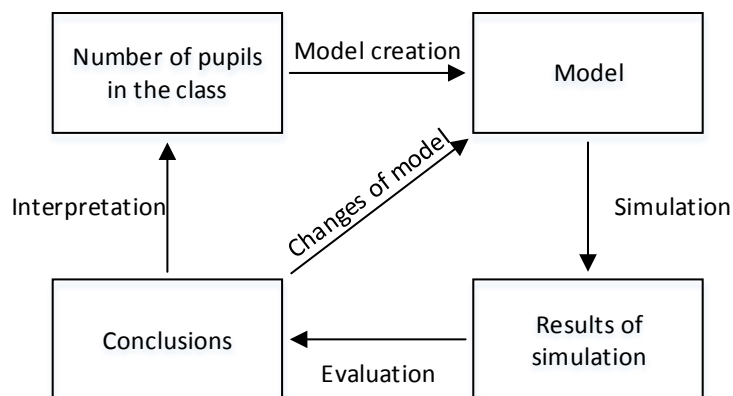
Figure 2. The procedure of model creation and interpretation of results arising from simulation.
For correct functioning of our model let suppose following:

- In case when there are too many pupils in the class the teacher cannot dedicate enough attention to each pupil and so it is important to give to pupils extra lessons at home. This work is a kind of unreasonable work for parents. It is not a work which would develop a social capital of a child or other capacities. Parent could so dedicate this time or to behavioral and knowledge education of their child joined to their social capital or to earning enough money to be able to support the development of social capital of the child.

- Giving extra lessons to pupil at home by parent increase linearly to increasing number of pupils in the class   of one teacher.

- When there is 1 pupil in the class it is not important to give extra lessons to pupil at home.

- The minimization of the sum of cost functions for pupil´s education at school and at home is the most effective possibility of education pupils for the society.

It is important to be recalled that:

- Education at home is giving extra lessons when parent replace the teacher with the aim that the pupil reaches required results (knowledge).

- Educating by parent at home is possible to divide into 2 domains. The first one is giving extra lessons to pupil for purpose to adopt capabilities which were not adopted at school for different reasons (e.g. improving correct handling of the pen, how to work with map etc.). The other one is educating by parent at home by reason to obtain other/additional capabilities beyond the school´s program. Often this second meaning is overlapping with behavioral education. In this case is considered the development of child´s social capital. This kind of home education by parent we will not consider in our model.
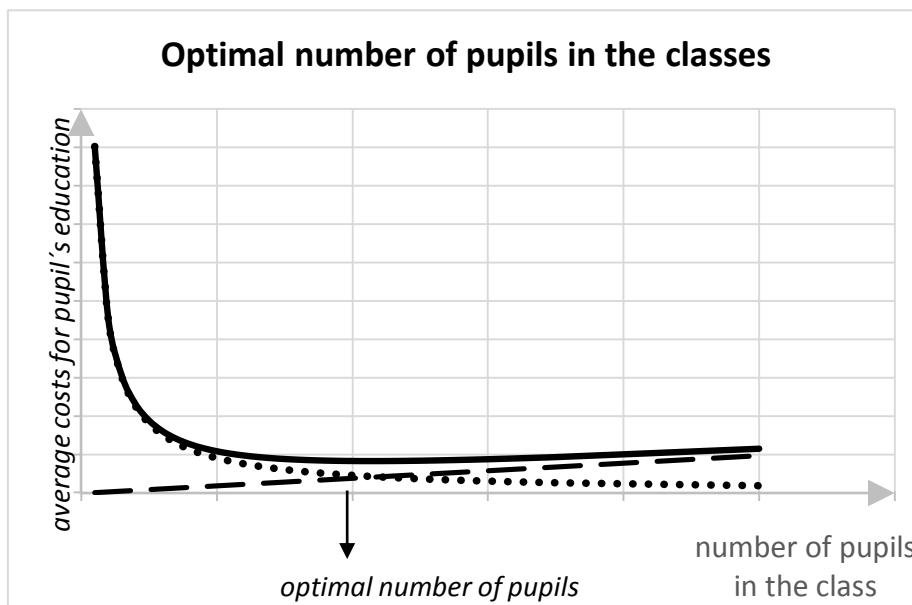
3. Graphical interpretation of the model

Figure 3. The model of optimal number of students in the class.

The graphical model (see fig.3) contains cost function of average costs for education of pupil at school (dotted line). It is obvious that this function is decreasing because when the number of pupils in the class increase, the average cost of teacher per pupil is divided among all members of the class. The dashed line presents the function of average cost for giving extra lessons to pupils at home. From the presumption of this model creation results the fact that this function linearly increase with an increasing number of pupils in the class. The average costs function of children´s education (thick top line) – from the economical point of view or more precisely from the society´s point of view – arises as a sum of average cost function for education at school and of average cost function for giving extra lessons to pupils at home.

To be able to conclude if the number of pupils in the classes is optimal from the socio-economic point of view it is important to know, where is located the minimum of the function of sum of average costs. The task is so to find the minimum of the function. In practice, this problem is usually solved by means of operational analysis and by mathematical methods.

4. Simulation

In Slovakia, the average gross salary of a teacher at basic school is 902 Euro (Folentova, 2016). Due to actual sources (UIPS, 2015) the average number of pupils in classes is 18,6. So the average costs per pupil at school is 48,49 Euro. Hereby the average gross salary in national economy in Slovakia is 858 Euro (Folentova, 2016) or 5072 Euro/hour. We also know that giving extra lessons at home is not necessitated in case when there is one pupil in the class. Also, by the analysis of the situation in Slovakia (our own research) we suppose that it is important do give extra lessons (lasting 30 minutes a day) at home to each pupil in case they are 30 in the class. From these data it is possible to create a function for the length of time of giving extra lessons at home for Slovakia:

$$y = -0,0172 + 0,0172x$$

where y is an average time of given extra lessons at home and x is the number of students in the class. Due to data from the table 1 it is possible to say, that nowadays the number of pupils in classes is not set optimally. Costs resulting from having 18,6 pupils (in average) in class are equal to 83,13 Euro per pupil. It is possible to deduce from analysis that the optimal number of pupils in classes considering actual conditions (actual teachers´ salary) in Slovakia is equal to 21. An appropriate solution would be to reduce teachers´ salary. This is highly improbable in actual conditions of society functioning in Slovakia as there are on the present totally opposite tendencies in Slovakia.

In accordance to OECD (2012) beginning teachers in basic schools in Slovakia have the lowest salaries from all countries and same in Slovakia there is the lowest ratio between the salary of teacher and the salary of university graduate. A solution would be to check average salary in these countries, to check the average salary of teachers in these countries and the average number of pupils in their basic schools. After that it would be possible not only to evaluate the model from the socio-economic point of view (impact of costs on society) but also in context with other countries of European Union.

Table 1. Total average costs for education per pupil in Slovakia.

Number of pupils in the class	Costs of teacher per 1 pupil at school [EUR]	Length of given extra lesson [h]	Costs for giving extra lessons [EUR]	Sum [EUR]
1	902,00	0,00	0,00	902,00
2	451,00	0,02	1,97	452,97
3	300,67	0,03	3,94	304,60
4	225,50	0,05	5,90	231,40
5	180,40	0,07	7,87	188,27
6	150,33	0,09	9,84	160,17
7	128,86	0,10	11,81	140,66
8	112,75	0,12	13,77	126,52
9	100,22	0,14	15,74	115,96
10	90,20	0,15	17,71	107,91
11	82,00	0,17	19,68	101,68
12	75,17	0,19	21,64	96,81
13	69,38	0,21	23,61	93,00
14	64,43	0,22	25,58	90,01
15	60,13	0,24	27,55	87,68
16	56,38	0,26	29,52	85,89
17	53,06	0,28	31,48	84,54
18	50,11	0,29	33,45	83,56
18,6	48,49	0,30	34,63	83,13
19	47,47	0,31	35,42	82,89
20	45,10	0,33	37,39	82,49
21	**42,95**	**0,34**	**39,35**	**82,31**
22	41,00	0,36	41,32	82,32
23	39,22	0,38	43,29	82,51
24	37,58	0,40	45,26	82,84
25	36,08	0,41	47,22	83,30
26	34,69	0,43	49,19	83,88
27	33,41	0,45	51,16	84,57
28	32,21	0,46	53,13	85,34
29	31,10	0,48	55,10	86,20
30	30,07	0,50	57,06	87,13

5. Conclusion

The number of pupils per one teacher is a very sensitive issue and different specialists have different opinions on it. There are many studies which did not declare a statistically important influence ... In about 15% of studies is said that pupils are doing better in smaller classes. Appropriately the same amount of studies claims that pupils are not doing very well in small classes. Conclusions say that the quality of teacher is more than the size of the class.

Our simulation is a contribution to discussion concerning future strategy of schools´ network optimization in particular conditions of Slovakia.

In the future we would like to analyze by the same way also other surrounding countries. We would like to attach a particular attention to countries which have in general the best educative system, such as Finland. Due to analysis of these countries we would like to collect interesting information about functioning of education in these countries also in context with the height of teachers´ salaries. With our deepen findings and our model we would like to contribute to expert discussion in this domain.

Acknowledgements

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