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THE IMPACT OF PISA STUDIES ON THE ITALIAN NATIONAL SERVICE OF ASSESSMENT

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In this chapter we will sketch how the discussion originated in Italy by the disappointing results of the first PISA studies was the origin of a National assessment program that possibly led some improvement in the results of mathematics learning. We will also underline similarities and differences between PISA studies and the Italian program of assessment.

INTRODUCTION

A discussion about the PISA program in Italy started, at least within the teachers, from the 2003 results, when Italy classified below the OECD mean. The teachers most engaged in the innovative programs perceived them as an alarm bell concerning the state of teaching/learning in the Italian schools at the end of the compulsory cycle, which in Italy ends at 16 years.

From this point of view, it is interesting to consider the changes (if any and of what nature) of the PISA results for mathematics in the following years.

In fact, some elements have not changed: e.g. the results continue to be below the OECD mean and there is a great variability between the Italian regions. Specifically, while in Northern regions there are results above the OECD mean, the opposite happens in the Southern Italian regions. However, from 2003 to 2009 in Mathematics there is a positive trend, with an increase of 17 points (see Fig. 1). This better performance is due above all to the better results in Southern regions, particularly from 2006 to 2009 (see Fig. 2): even if they remain below the OECD mean, they show a better performance.

INSERT FIG. 1 MORE OR LESS HERE

INSERT FIG. 2 MORE OR LESS HERE

IN-SERVICE TEACHERS' TRAINING PROGRAMS ABOUT PISA STUDIES

Because of the 2003 and 2006 PISA results, the Italian Ministry of Education (MIUR) in 2008 launched the program “*Piano di informazione e sensibilizzazione sull’indagine OCSE-PISA e altre ricerche internazionali*” (Plan for information and awareness about the OECD-PISA study and other international researches). Such a program has been funded with European money and its aim is supporting the innovation and quality of teaching in the schools of four Southern Italian regions (Calabria, Campania, Puglia e Sicilia) in order to bridge the gap measured by PISA with respect both to other Italian regions and to the states of the European Union. These regions were chosen since they have a GDP at least 75% less of the 25-states-

Europe mean.

The program started in 2008-2009 and involved the teachers of Italian, Mathematics and Science of the first two years of upper secondary school (grades 9 and 10) in all the four regions schools (altogether 20,000 teachers). Then it continued in successive years, as described below.

The main goals of the program are:

- informing teachers about the OECD-PISA study in a clear and correct way;
- analysing the PISA framework for Mathematics, particularly the structure of the test and the public items;
- comparing them with the most diffuse didactical practices in Italian classrooms;
- analysing the results of the Italian students in the PISA study.

The program consists in a two-days seminar, and in ad hoc materials the teachers have to study and discuss together, once back in their schools.

In the years, it became apparent that the mathematical competences considered in PISA are not only the exclusive concern of the grade 9-10 teachers, who are directly involved in PISA testing, but must be built up in longer periods of time, starting from the very beginning of school curricula.

Hence, after 2009 the project has been enlarged to the teachers of primary and lower secondary schools: currently it concerns particularly the teachers from grade 6 to 8.

In the years an additional argument has been added to the list of those covered by the seminar: the PISA framework is compared with that used by the Italian Assessment Service (SNV: Servizio Nazionale di Valutazione), which started its work in 2008. Indeed, in the Italian context, the use of standardized assessment (SNV) has assumed an increasing importance only recently, thanks to the annual surveys conducted by the National Evaluation Institute for the School System (INVALSI <http://www.invalsi.it/invalsi/index.php>) at different school grades. The INVALSI develops standardized national tests to assess pupils' reading comprehension, grammar knowledge and mathematics competency, and administers them to the whole population of primary school students (2th and 5th grade), lower secondary school students (6th and 8th grade), and upper secondary school students (10th grade). The action of information and awareness in the years has involved almost the totality of teachers in Southern Italy. Hence it is plausible that that the development of a national assessment service has caused the positive trend in the last PISA results, illustrated in Figure 2.

Furthermore, from 1995 Italy participates also in TIMSS program, which aims at measuring students' competencies in mathematics and science at grades 4 and 8. Also in this case, and particularly in 2007, the results of the Italian students have been very disappointing: Italy position in the TIMSS downgraded dramatically from previous positions.

But something new for Italy happened from 2008: exactly from that year in Italy all students in grade 8 had to face a final standardized test on mathematical

competencies (up to that date nothing similar existed), the above mentioned Italian Assessment Service (SNV).

In fact, in the successive TIMSS testing in 2012 Italy showed the best increase in results with respect to the previous one. This improving permitted to Italy to classified itself at the international mean level.

Of course it is too crude postulating a cause-effect phenomenon between the introduction of the Italian Assessment Service (SNV) testing and this sensible improving. However such a concomitance is a fact and this event is the only real change that happened in the Italian school in the period 2007-2012. It is more than an impression that the introduction of the standardized tests at the end of the lower secondary school has represented a strong innovative component, which has produced an innovation and a revision of the practices in the school.

Certainly all the methodological-didactic implications must be deepened, but there is no doubt that the introduction of standardized tests has been a strong element for triggering and supporting the revision of the teaching methods adopted by teachers in schools.

Another possible cause of PISA-driven changes in the Italian schools teaching practises may be due to another big teachers education program, promoted by the MIUR from 2008: the *m@t.abel* project. It is an acronym that in Italian means *basic mathematics with e-learning*: in fact teachers, divided in virtual classes of 20 persons under the guidance of an experienced trainer, share the materials of the course and discuss what happen in their classrooms when they experiment the teaching units of the project. It involved 5000 teachers from grade 6 to 10 all over Italy and moreover most of the teachers from the same four Southern Italian regions listed above. The main aim of *m@t.abel* consists in providing examples of best practices in the classroom, which often are drawn in coherence with the PISA framework. We have not the space to discuss it here. The reader can find more information downloading an informative booklet from

<http://mediarepository.indire.it/iko/uploads/allegati/M7PWITOE.pdf>, where also the relationships between the Italian project and the PISA study are made explicit.

Many of the teachers of the other program participated also to this one: so they could find in the materials of *m@t.abel* many examples of activities that performed most effectively in the classroom what is stated theoretically in the PISA framework.

RELATIONSHIP BETWEEN ITALIAN NATIONAL ASSESSMENT SERVICE AND PISA MATHEMATICS FRAMEWORKS

The 2003 and 2012 PISA framework for Mathematics has certainly influenced the construction of the Reference Framework for Mathematics of the National Assessment Service, which was concretely designed and performed by INVALSI. The SNV investigation aims photographing the school as a whole: in other words, it is an evaluation of the effectiveness of education provided by the Italian school. Currently, standardized tests are administered to the following cohorts of students: 2th and 5th grade (primary school), 6th and 8th grade (lower secondary school) and

10th grade (upper secondary school). The 8th grade test is included in the final examination at the end of the first cycle of instruction: its main aim is providing teachers with a tool shared on the national territory for the assessment of their students. The SNV test is carried out every year and is censuary, since it involves all students of the Italian classes attending that grade (for example all the Italian 8th grade students). The results of the sample, stratified by regions, are returned by INVALSI in an annual report. The data are disaggregated by gender, citizenship and regularity of schooling: they are public, as well as the trials and the correction grids. On the contrary, the results of each school are sent confidentially to the principal of the school and are normally provided at the beginning of the school year immediately after the test.

There are at least three main differences between SNV tests and PISA studies: the frequency (annual vs triennial), the type of tested population (census vs. sample size) and the chosen sample (grade-based vs. age-based students).

The preparation of the items is performed in two steps. A first set of items are prepared by in-service teachers of all levels, who are also asked to classify them according to the SNV framework (question intent, processes involved, precise links with the National Guidelines). Subsequently, the SNV National Working Group builds the test choosing those questions from the set above, so that the test is balanced both from the point of view of content and of processes. It is, however, important to point out that the methodological and statistical methods underpinning both studies (SNV and PISA) are basically the same. The Reference Framework for Mathematics in SNV has its roots in the National Guidelines for the Curriculum and in some teaching practices that have consolidated over the years. Another important reference is the UMI-CIIM curriculum "Mathematics for the citizen" (Anichini et al., 2004), which, on its side, is based on results of Mathematics education research and has deeply influenced both the last formulation of the National curriculum and the m@t.abel program.

Specifically, there it is explicitly stated the necessity of taking "into account both the instrumental and the cultural function of mathematics. [...] Both aspects are essential for a balanced education: without its instrumental features, mathematics would be pure manipulation of signs without meaning; without a global vision mathematics would be a series of recipes without method and justification" (ibid. p. 7).

The SNV Framework defines what type of mathematics is assessed with the SNV tests and how it is evaluated. It identifies two dimensions along which the questions are built:

- the *mathematical content*, divided into four major areas: Numbers, Space and Figures, Relations and Functions, Data and Forecasts;
- the *processes* that students should activate while solving the questions of the items.

As to this subdivision into four main areas, it must be said that this idea is now shared at the international level: in Pisa we have four content categories (Quantity, Space and shape, Change and relationships, Uncertainty and data) and in TIMSS we have four content domains (Number, Geometry, Algebra, Data and chance).

As one can see, the differences are minimal and the four areas identify the same categories of mathematical content, even if one can observe different choices according to the idea of what kind of mathematics the items are scrutinizing and assessing. The Italian choice has been to appoint areas through the involved mathematical objects and not with the academic name of the discipline, which has its own well defined epistemological status (e.g. Space and Figures and not Geometry). This choice is in line with the *national curriculum* but is a novelty with respect to the traditional one.

Concerning the processes, we can observe that also the PISA 2012 framework, unlike the framework PISA 2003, moves towards this direction albeit with a definition of mathematical literacy focused on the mathematisation cycle.

In order to build up the items and to analyse the answers, the SNV study considers the following types of processes involved in the tests solution:

- i. *knowing and mastering the specific contents of mathematics;*
- ii. *knowing and using algorithms and procedures;*
- iii. *knowing different forms of representations and passing from the one to the other;*
- iv. *solving problems using strategies within different areas: numerical, geometrical, algebraic, etc.;*
- v. *acknowledging the measurability of objects and phenomena in different contexts, using measuring tools, measuring quantities, estimating such measures;*
- vi. *using typical forms of the mathematical reasoning (conjecturing, arguing, verifying, defining, generalizing, proving,...);*
- vii. *using tools, models and representations in in the quantitative treatment of information scientific, technological, economic and social environments;*
- viii. *recognizing shapes in space and using them to solve geometric or modeling problems.*

Starting from 2013, SNV adopted a further processes classification, the same used by PISA (Formulate, Employ, Interpret) in order to allow an easier comparison among the two surveys.

The definition of the processes in PISA 2012 is centered more on the idea of mathematics as a means to analyze, interpret and represent real-world situations (cycle of mathematization). However, the processes examined by the SNV study are different : they include both aspects of mathematical modeling, as in PISA, and aspects of mathematics as a subject of study, namely as body of knowledge logically consistent and systematically structured, characterized by a strong cultural unity [Anichini & al., 2004].

The SNV Mathematics framework is a tool in evolution, in the sense that periodic updates are foreseen, also based on the experience gained in the field and the information from the world of school.

TWO EXAMPLES FROM THE SNV STUDY: MATHEMATICAL MODELING AND ARGUING

We sketch here two examples in order to highlight similarities and differences between the SNV and PISA reference frameworks and in the way mathematics is considered in the two studies.

The elongation of a spring

The first example concerns a question of mathematical modeling; it was proposed in SNV 2011. Two versions, with some slight differences, were prepared: one for grade 8 (at the end of the first cycle of schooling) and one for grade 10.

The two items (see Tables 1 and 2) are classified within the area Relations and functions and concern mainly process (vii).

D17. The formula $L = L_0 + K \times P$ expresses the length L of a spring, as the applied weight P changes. L_0 represents the length in cm of the spring “at rest”; K indicates how much the spring stretches in cm, when a unit of weight is applied to it.

Which of the formulas below represents better the following description:

“It is a very short and hard spring (hard means that the spring is very resistant to traction)”?

- A. $L = 10 + 0,5 \times P$
- B. $L = 10 + 7 \times P$
- C. $L = 80 + 0,5 \times P$
- D. $L = 80 + 7 \times P$

Table 1. SNV-INVALSI (2010-2011, 8th grade)

D24. The formula $L = L_0 + K \times P$ expresses the length L of a spring, as the applied weight P changes. L_0 represents the length in cm of the spring “at rest”; K indicates how much the spring stretches in cm, when a unit of weight is applied to it.

Which of the formulas below represents better the following description:

“It is a very long and hard spring (hard means that the spring is very resistant to traction)”?

- A. $l = 15 + 0,5 \cdot P$
- B. $l = 75 + 7 \cdot P$
- C. $l = 70 + 0,01 \cdot P$
- D. $l = 60 + 6 \cdot P$

Table 2. SNV-INVALSI (2010-2011, 10th grade)

Item	Omissions	OPTIONS			
		A	B	C	D
D17	4,0	58,3	25,4	7,9	4,3

Item	Omissions	OPTIONS			
		A	B	C	D
D24	11,8	8,1	33,2	38,1	8,9

Table 3. Percentage of answers in the national sample

To answer correctly, the student must be able to choose the formula that better represents the verbal description of the physical characteristics of a spring (very short / long and very resistant to traction).

The students must correctly interpret the meaning of the parameters of the function (L_0 and K) by combining the described physical characteristics with the parameters of the linear function that models the phenomenon.

It is not so much surprising that the results of students in the 8th grade are better than those of the 10th grade (Table 3), for at least two reasons. First the values of the parameters are different and those of the first application are easier to compare those. Second, it is usual in teaching practice in lower secondary school to represent physical phenomena through formulas and graphs, while this habit generally in secondary school is done only after grade 10; in grades 9 and 10 algebra is generally taught only at the syntactic level, at most to solve geometric problems and never to model physical situations: generally the curriculum postpones physics to grades 11, 12, 13 (Garuti & Boero, 1994).

The choice of option B (a student over 3 at the upper secondary level and one over 4 at the lower secondary level) is probably due to incorrect identification of words like "high values of K , high stretching"). In any case, the results to this question suggest a not yet sufficient attention to the use of simple models in the teaching practice.

Natural numbers: justifying and proving

The following example arises in the context of the latest Italian research in mathematics education (Mariotti, 2006; Boero & al., 2007): it somehow condenses the results of wide researches about the approach to argumentation and proof in mathematics, even with young students. Such researches have important implications in the field of educational research, and as a counterpart to this suggest strongly innovative teaching practices in the classroom. The example is classified in the area Numbers and relate to the process *vi* (see above).

In this item (8th grade, Table 4), students are required to develop arguments about the validity or non validity of a non-trivial statement: in fact they must choose both the right answer and the correct justification.

The teacher asks: "An even number greater than 2 can always be written as the sum of two different odd numbers? ". Below are the answers of four students. Who gives the correct answer and justify it properly?

A. Antonio: Yes, because the sum of two odd numbers is an even number

B. Barbara: No, because is $6 = 4 + 2$

C.	<input type="checkbox"/> Carlo: Yes, because I can write it as the odd number that precedes it, plus 1
D.	<input type="checkbox"/> Daniela: No, because every even number can be written as a sum of two equal numbers

Table 4. *SNV-INVALSI (2011-2012, 8th grade)*

Item	Omissions	OPTIONS			
		A	B	C	D
E13	1,5	44,0	6,4	34,0	14,0

Table 5. Percentage of answers in the sample

This item requires that the student understands that every even number greater than 2 can be written as $(2n-1) + 1$.

The chosen distractors correspond to more frequent observed behaviors of students in the researches quoted above: they all concern students' understanding and exploration of the statement. In particular, the distractor A, which had 44% of responses, corresponds to an inversion between the thesis and hypothesis: in fact to answer the question it is not relevant the fact that the sum of two odd numbers is even: on the contrary, the problem is to ascertain whether each even number greater than 2 is the sum of two (different) odd numbers. We consider this type of questions very important since:

- (i) they allow verifying mathematical skills typical of the cultural aspect of mathematics evoked by the National Guidelines using a standardized test;
- (ii) they show the teachers the possibility of using algebra as a tool for supporting reasoning and consequently they push the teachers towards a change of their practices as a result of the discussions made in their schools about the nature of SVN tests, so important for the evaluation of the Italian schools (see the discussions at the beginning and at the end of this chapter).

D11.

a. Observe and fill up the following table

n	$(n-1)n(n+1)$
2	1 x 2 x 3
3	2 x 3 x 4
4
5

b. Giulia says : «For each natural number n bigger than 1, $(n-1)n(n+1)$ is divisible by 6 ». Explain why Giulia is right.

c. Francesco says : « $n^3 - n$ is equal to $(n-1)n(n+1)$. Proof that Francesco is right.

Table 6. *SNV-INVALSI (2011-2012, 10th grade)*

	wrong	right	omissions
Item a	5,7	85,0	8,9
Item b	32,0	19,1	47,3
Item c	34,2	20,2	44,1

Table 7 Percentage of answers in the national sample

As pointed out above, this type of items is an important signal of reflexion for teachers in order that they consider the issue of approaching the culture of theorems in the school, which is a challenge to the teaching tradition. Usually in Italy (and possibly also in other countries) the teacher asks the students to understand and repeat proofs of statement supplied by him/her. The teacher generally asks students repeating proofs and not proving statements. Even more seldom students are asked to produce conjectures themselves or to find arguments in order to justify a statement. The aim of this type of item is to change the teaching practices in the school, because of the strong impact that the SNV tests have in teachers' practices.

In fact generally proving activities are not so common in the first years of Italian secondary schools, particularly as far as the use of algebraic machinery is concerned. Most practices in algebra in grades 9 and 10 concern more the manipulative aspects of formulas and not their use as thinking tools that can support the mathematical reasoning (Arzarello et al., 1997). This appears only later and only in some types of schools (more scientifically oriented, with a stronger curriculum of mathematics), when Elementary Calculus is introduced.

CONCLUSION

In this chapter we have shortly illustrated how the debate originated from the disappointing results of Italian students in 2003 PISA study had a positive fall out in the country. First, it convinced the Ministry of Education to design a National policy for assessing the quality of teaching in the school through the institution of a National Service for Evaluation (SNV). From 2008 it started a systematic censuary survey each year at different grades (2, 5, 6, 8, 10). Second, the Ministry promoted seminars about the meaning of PISA studies and innovative programs for the teaching of mathematics, which involved a considerable number of Italian mathematics teachers.

All these PISA-driven initiatives in Italy have possibly had a positive influence on the last years' international assessment studies.

We have also exemplified how the framework of the SNV is strongly coherent with that of PISA. A peculiar feature of the Italian items, which possibly distinguishes them from those of PISA, is a stronger presence of items where students are asked of arguing and proving: this aspect is due to a typical specific Italian tradition in the teaching of mathematics.

References

- Anichini, G., Arzarello F., Ciarrapico, L. Robutti, O. (Eds.). (2004). New mathematical standards for the school from 5 through 18 years, The curriculum of mathematics from 6 to 19 years, on behalf of UMI-CIIM, MIUR (edition for ICME 10). Bologna: UMI.
- Arzarello F., F., Bazzini, L., Chiappini, G. (1997). A model for analysing algebraic processes of thinking. In: (Ed.) Sutherland, R. The teaching of Algebra. Kluwer Publ. Co.
- Garuti, R., Boero, P., (1994), Mathematical modelling of the elongation of a spring: given a double length spring..., in Proceedings PME XVIII, Lisboa (Portugal).
- Mariotti M.A. (2006), Proof and proving in mathematics education, in Handbook of Research on the Psychology of Mathematics Education, A. Gutierrez an P. Boero (Eds), Sense Publishers.
- Boero, P., Garuti, R. & Lemut, E., (2007) Approaching theorems in grade VIII, in Theorems in School, Boero P. (Ed.), Sense Publisher.

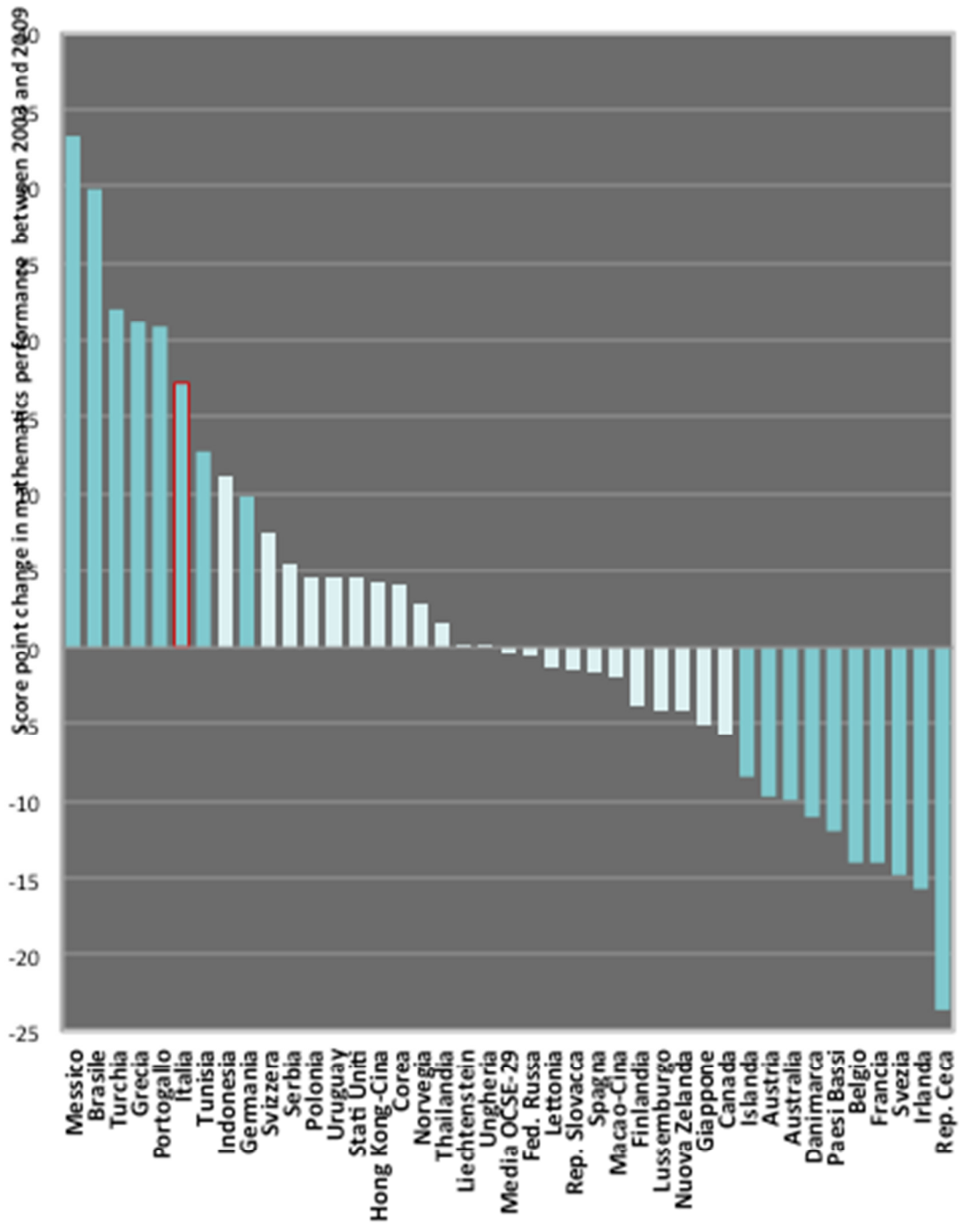


Figure 1

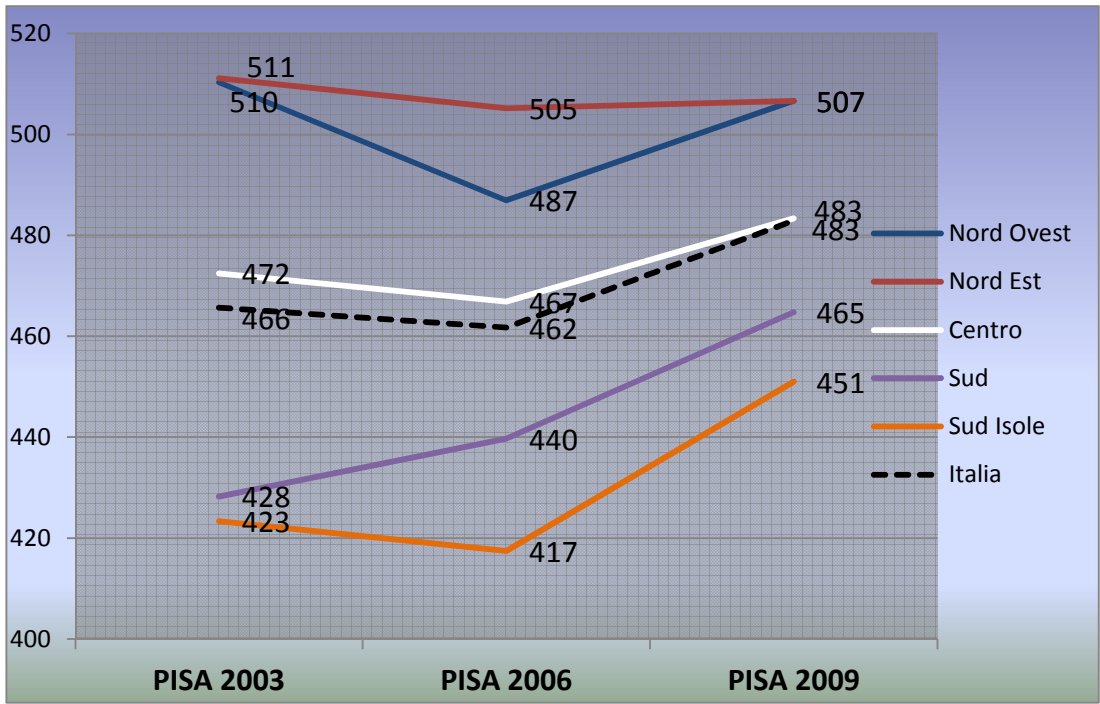


Figure 2