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Sharing Inspiration 2019
The Power of Realization

Brussels, 29th-31st March 2019

Mathematics in Bac examinations in Italy: subjects, type of questions and the graphic calculators impact

Luigi Tomasi, T³ Italy

Presentation (Round 2)

Brussels, Sunday, March 31st, 2019

10:00am-11:00am

Abstract

This paper deals with some problems and questions that have been assigned in the written state exam of the "Liceo Scientifico" in the last two years (2017 and 2018) when the use of non-CAS graphic calculators was allowed. Also, the impact of the use of these tools, of the teachers' attitudes towards these tools, the training on graphic calculators and the restricted diffusion of the use of these tools in examinations will be discussed here. We will also consider the possible reasons for the limited use of graphic calculators by the teachers in Italy.

Luigi Tomasi, T³ Italy

Outline/schedule

- Legislation **in Italy**
- Considerations
- The use that teachers make of graphic calculators as well as technology in general
- What should be done?

The use of graphic calculators in BAC examinations in Italy since 2017

- In May 2017 the Italian Ministry of Education notified that in the written state exam students could use a non-CAS graphic (as well as a standard scientific) calculator
- At the beginning of October 2018 the Ministry informed the students that the use of the same type of calculator was allowed. This has favoured an appropriate educational planning.

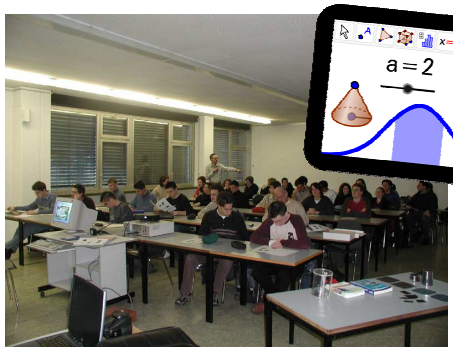
Why a graphic calculator?

- The use of the graphic calculator in the BAC examinations had been requested by many maths teachers for several years.
- As a matter of fact, about 15 years ago some teachers even asked for permission to use the CAS calculators since they were interested in the renewal of maths teaching and the didactic use of technologies.
- In Italy, the Ministry accepted this request and adjusted Italian school to what was happening in other European countries and in the world.

But the answer came too late…

- The use of this kind of calculator was allowed only in 2017…too late….
- In the last years other tools have been used….
- It cannot be considered an innovation anymore…..
- Some teachers are convinced that graphic calculators represent an outdated form of technology compared to other more modern technologies…
- The use of the graphic calculator is not compulsory!

The legislation on the use of technological tools in curricula (for teachers) in Italy



The legislation and the curriculum on the use of technological tools in Italy

This is an innovative perspective that has been part of all curricula since 2010 or even before in Italy.
It refers to the role and use of IT tools in teaching and/or learning mathematics.

Methodological recommendations: the use of IT tools in Italian curricula

«*The IT tools that are available nowadays offer a suitable background to represent as well as handle maths contents.*
The teaching of mathematics offers several opportunities to become familiar with these tools and to understand their ***methodological value****.*»

Methodological recommendations: the use of IT tools in Italian curricula

In the National recommendations for the "Licei" we can read:

"The use of IT tools is an important resource that will be introduced critically, without creating the illusion that it is an automatic means of solving problems and without compromising the necessary acquisition of mental computing skills".

"The student will develop his/her skills in the calculation (mental, with paper and pen) using appropriate tools".

Methodological recommendations: the use of IT tools in Italian curricula

In the ***Guidelines*** (2010) for Technical and Vocational Schools we find the following references to the use of technological tools:

"Analyze and understand data ... knowingly using calculation tools and the resources offered by the implementation of specific IT applications "

"Use the procedures of arithmetic calculation (in mind, in writing, by machine)".

Some challenges for maths teachers (not only in Italy…)

If we integrate these technologies into everyday teaching we will have the following results:

- Changes in the type of activities proposed: higher focus on reasoning, on the procedure, on mathematical modelling, ...
- Changes in assessment: with the use of these tools we will become acquainted with new forms of knowledge, skills and competences that need to be developed and evaluated;
- Teachers are asked to consider the didactic use of these tools.

Something important students should be aware of:

- In order to use a graphic (and/or scientific) calculator correctly, students need to have a certain degree of knowledge of mathematics!

Graphic calculators: educational and didactic analysis

- The use of a graphic calculator cannot suddenly change a student's performance for good, but it can make the student feel more self-confident.
- The graphic calculator can be very useful when you need to visualize a graph quickly or explore some of its properties.
- During the state exams at "Liceo scientifico" students are asked mainly questions regarding calculus.

Graphic calculators: educational and didactic analysis

- What happens if a student cannot understand or explain the graph he/she sees on the display?
- The use of a graphic calculator during the exam must therefore go together with the daily use of it in class and an appropriate knowledge of mathematics: this is the only way to make the tool really useful.

Tools and Technologies used in learning and teaching maths

Teachers (not all…) used different kinds of software to teach maths, in particular GeoGebra,… Cabri-geometry and Derive up until a few years ago.

Tools and Technologies used in learning and teaching maths

- Calculators, which are found in smartphones, tablets and even watches…..
- Any kind of Applet for maths in smartphones (for example Desmos, Wolfram Alpha, MalMath,…)

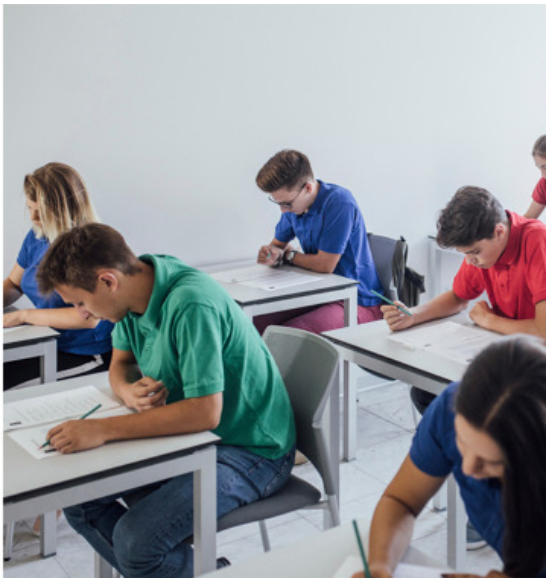
But only scientific and graphic (non-CAS) calculators can be used at the high school state exam in Italy!

The graphic calculator is a tool that should be used in didactics

The T³ Italian educational trainers give these recommendations to maths teachers:

- The graphic calculator should be used in class in everyday activities, together with other tools;
- It shouldn't be used only in view of the written exam
- The calculator is a tool that must be used «to do» mathematics
- The graphic calculator shouldn't be considered an exclusive tool, but it should rather accompany other tools.

Types of problems and questions assigned in the written exam test at the Liceo Scientifico in 2017 and 2018 in Italy (Bac exam in Italy, only at "Liceo Scientifico")



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Liceo scientifico – Written exam test 2017– Problem n. 1 (the squared «wheel»)

Figura 1

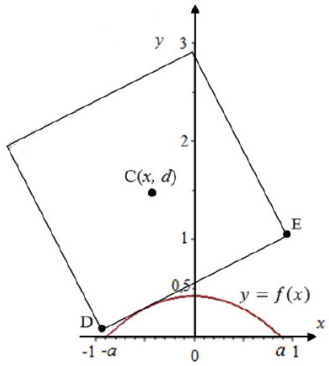
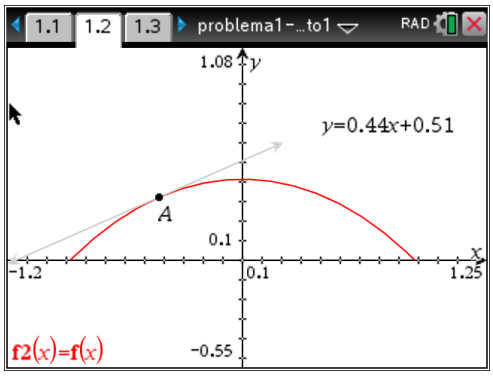


Figura 2

Liceo scientifico – 2017 Written exam test – Problem n. 1 (The squared «wheel»)



Liceo scientifico – 2017 Written exam test – Problem n. 2

Given the function f(x)

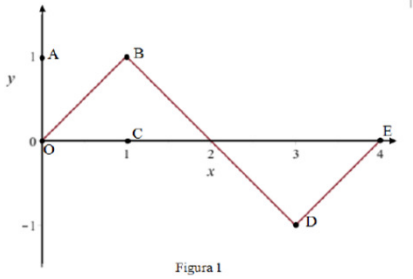


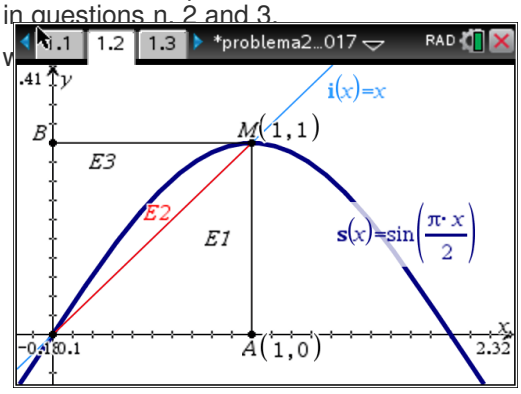
Figura 1

Represent the graphs of the derivative g(x) = f'(x) as well as the integral function:

$$h(x) = \int_0^x f(t)\,dt$$

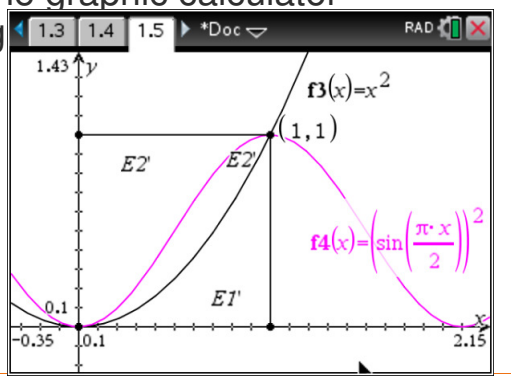
Liceo scientifico -2017 written exam test– Problem n. 2

- The graphic calculator could have been useful to draw the graphs of the functions required in this problem, especially in questions n. 2 and 3.
- As to question n. 2, v
graph.



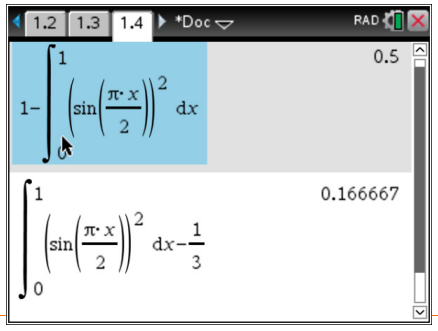
Liceo scientifico -2017 written exam test– Problem n. 2

- With reference to question n. 3 thanks to the use of the graphic calculator the following g drawn.



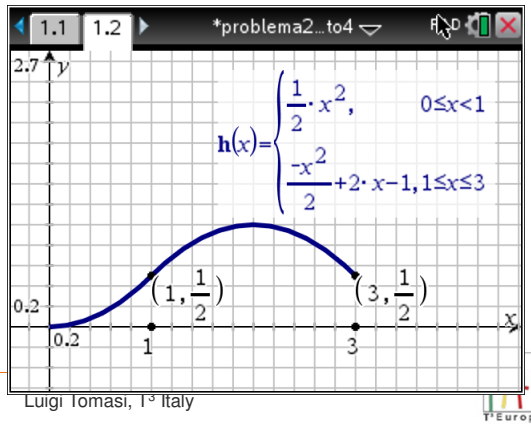
Liceo scientifico -2017 written exam test - Problem n. 2

- As to question n. 3, the use of the graphic calculator could have helped performing the following calculations



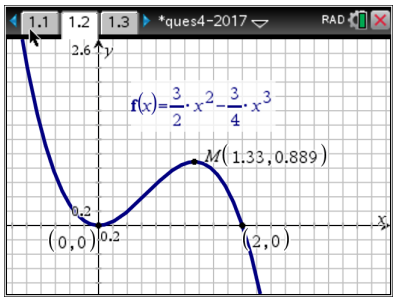
Liceo scientifico -2017 written exam test– Problem n. 2

- With reference to question n. 4 the following graph could be drawn for the integral function



Liceo scientifico -2017 written exam test– Question n. 4

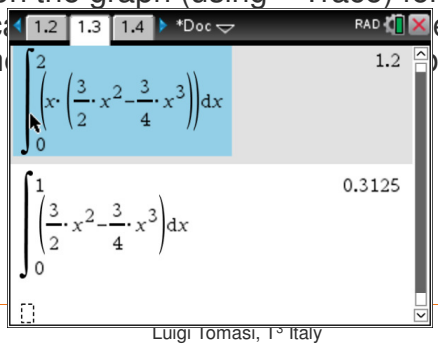
- The graphic calculator could be of some help in drawing quicky the graph, the density of probability (a cubic one) and to explore the function values by means of the cursor placed on the graph (using → Trace) for the numerical calculation of the mean value and the numerical calculation of the probability.



$$f(x)=\frac{3}{2}x^2-\frac{3}{4}x^3$$

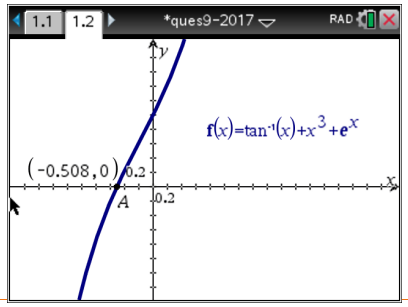
Liceo scientifico -2017 written exam test– Question n. 4

The graphic calculator could be of some help in drawing quickly the graph, the density of probability (a cubic one) and to explore the function values by means of the cursor placed on the graph (using →Trace) for the numerica… e and the num… ility. $f(x)=\frac{3}{2}x^2-\frac{3}{4}x^3$



Liceo scientifico -2017 written exam test– Question n.9

- The graphic calculator could have been useful to draw quickly the graph of the function, possibly the first derivative and to identify an approximation of the only solution by graphics using Trace and Zoom.



Liceo scientifico -2018 ??????????????

- The graphic calculator could have been useful to draw quickly the graph of the function, possibly the first derivative and to identify an approximation of the only solution by graphics using Trace and Zoom.

In 2019 the Italian Ministry of Education stated that the written exam test would cover both Mathematics and Physics for the «Liceo Scientifico».
Let's analyze some problems taken from the mock examination of February 28th 2019.

Soluzioni alla simulazione della seconda prova della maturità 2019

Liceo Scientifico

Si è svolta in data **giovedì 28 febbraio 2019** la simulazione della seconda prova della maturità 2019. Con la **Circolare prot. n. 3050 del 4 ottobre 2018**, il Ministero ha decretato che quest'anno la seconda prova scritta sarà multidisciplinare, gli studenti del Liceo Scientifico dovranno quindi affrontare durante l'esame due materie: matematica e fisica.

Problem n. 1 (mock test 28th February 2019)

After allocating two real constants a and b (with a> 0), consider the function q (t) defined as follows:

$$q(t) = a\,t\,e^{bt}$$

1. Depending on the possible values of a and b, discuss whether there is a maximum or minimum point in the graph of function q. Determine the values of a and b at which the graph of the q (t) function, in a Cartesian coordinate plane (t, y), has a maximum at

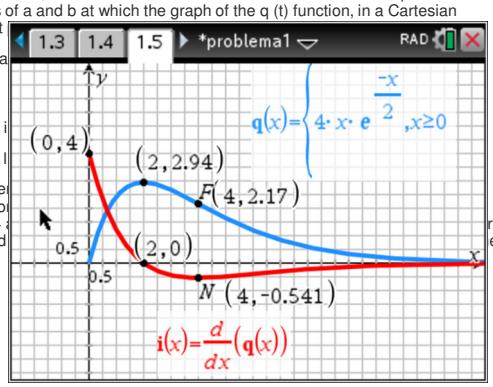
2. Assuming, from now on, to have a = 4 a

$$q(t) = 4t\,e^{\wedge}(-t/2)$$

checking, in particular, that there is an i

Determine the equation of the tangent l

3. Assuming that the function q (t) represe instant of time t (measured in s) the sectio constants a and b above. Assuming a = 4 time t; determine the maximum value and passage of time.



Requirements of problem n. 1

- The problem starts with mathematics to get to physics.
- Parametric problem with parameter determination
- Traditional function study: the student is definitely favoured by the use of a graphic calculator.
- The student who can use the graphic calculator cannot fail to build the graph: he must know how to justify his/her choices

Problem n. 2

- Verify that, if the charge $Q2$ is at the point of the line r with abscissa x, the potential electrostatic energy of the system consisting of $Q1$ and $Q2$ is given by

$$\mathcal{U}(x) = k\,4q\,2$$
$$\sqrt{1 + x\,2}$$

where k is a positive constant (unit of measure: N · m²/ C²).

3. Study the function $\mathcal{U}\,(x)$ for $x \in \mathbb{R}$, specifying any symmetries, asymptotes, maxima or minima, flexed. What are the angular coefficients of the tangents at the inflection points?

4. Starting from the graph of the function $\mathcal{U}$, plot the graph of the function $\mathcal{U}$ 'specifying any

- symmetry properties. Determine the value of $\int \mathcal{U}'(x)\; m\; -m\; dx$ (where $m > 0$ indicates the abscissa of the point of minimum of $\mathcal{U}$ '

Requirements of problem n.2

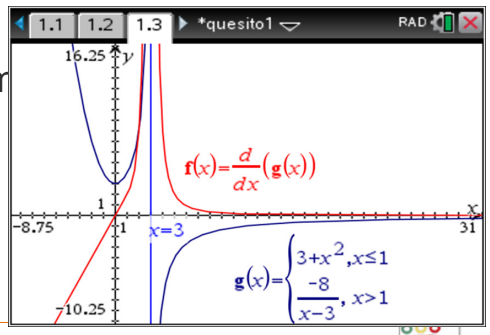
- The problem starts from physics to get to mathematics
- It is a traditional study of function: the student who has the chance to use a graphic calculator is definitely favoured even if he/she is specifically asked to substantiate his/her choices. The question regarding the final integral calculus is quite easy.

Question n. 1

- Determine the values of *a* and *b* in such a way that the function

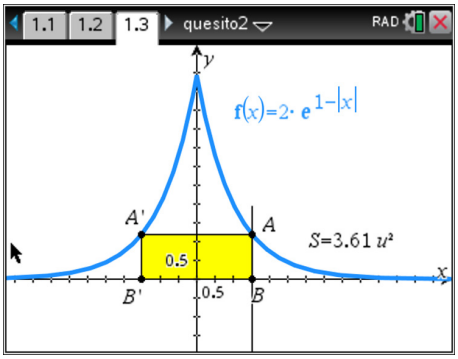
$$g(x) = \begin{cases} 3 - a\,x^2 & \text{if } x \le 1 \\ b/(x-3) & \text{if } x > 1 \end{cases}$$

is derivable in all its dom
the functions g and g'.



Question n. 2

If $\mathcal{R}$ is the flat region between the x axis and the equation curve $y = 2e^{1-|x|}$ demonstrate that, between the rectangles inscribed in $\mathcal{R}$ and having one side on the axis x, the maximum area has a minimum perimeter when $\mathcal{R}$ is a square.



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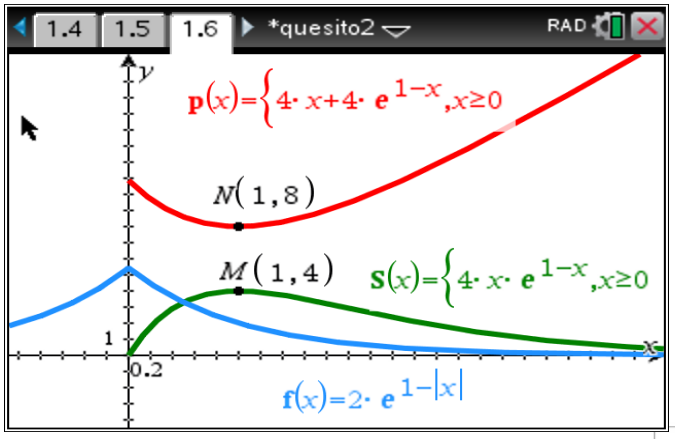
Question n. 2



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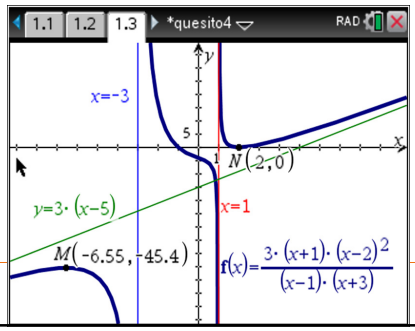
Question n. 4

Write, justifying your choice, a rational function $y=s(x)/t(x)$, where $s(x)$ and $t(x)$ are polynomials, in a way that the graph of the function:

- meets the axis x in the points of the abscissa –1 and 2 and is tangent to it in this latter point;
- has vertical asymptotes of equations $x=-3$ and $x=1$;
- Passes through the point $P(7, 10)$.

Represent the graph of the resulting function (in a qualitative way) .

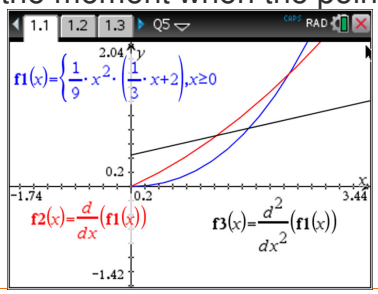


Question n. 6 (Physics)

A material point moves in a straight line, according to the expressed time law, for t≥0, from

$$x(t) = 1/9\ t^2\ (1/3\ t + 2)$$

where $x(t)$ indicates (in m) the position occupied by the point at time t (in s). Is it a uniformly accelerated motion? Calculate the average speed in the first 9 seconds of motion and determine the moment when the point moves at this speed.



Use of a non-CAS graphic calculator

- The use of calculation tools is allowed, but it is not mandatory ("*The use of scientific and / or graphic calculators is permitted as long as they are not equipped with symbolic calculation powe*r (cit. from OM No. 350, 2018, Art. 18 para. 8) ",
- We can notice that in most of the questions, the use of graphic calculators can help the students in performing calculations and in drawing the different graphs required.

Problems and questions seem to not be designed for a specific use of the graphic calculator…

- However the problems and the questions we find in these tests (of Mathematics and of "Mathematics and Physics") do not seem proper for the specific use of a graphic calculator (not CAS).
- They can be solved even without the use of a calculator
- Still, there is no doubt that the use of a graphic calculator is always an advantage for the student.

Use of the graphic calculators and the exam tests

In the example of Mathematics and Physics the graphic calculator can be used in problem n. 1 (in particular in the maths questions n.1 and 2), in problem n. 2 (particularly in questions n.3 and 4 to draw the graph of the functions quickly) and in the majority of the questions.

The use of graphic calculators and the exam tests in Italy

- Thanks to the use of a graphic calculator you can obviously draw a graph in a very short time or quickly check if a function corresponds to the calculations performed.
- It is however necessary for the student to know how to substantiate what he observes in the calculator display and complete the symbolic calculations by hand.

Use of the graphic calculator in the February 28th mock test

In the mock test of February 28th students could use the graphic calculator both in the problems and in the questions which call for the presence of graphs.

In some questions, parameters are used and therefore the student is asked to use sliders to represent them appropriately in the graphic calculator.

Exam questions and the use of the graphic calculator

It must be noted that in this kind of test the student is free to make his/her own decisions as to the use of the graphic calculator. However, in the previous years (2017 and 2018), when the use of the graphic calculator was allowed, only a small portion of students used it.

Use of graphic calculators and classroom work

There are several levels in the use of graphic calculators.
The simple graphic assessment can be paired with a more extensive use that can exploit the interaction between the different settings.
This use should be guided during schoolwork.
In these tests the type of questions may be more or less suited to the use of calculators, even if we must admit it isn't often necessary.

Part Two
Some considerations and observations on teachers, students and graphic calculators

How to convince our colleagues to use a graphic calculator in their way of teaching in Italy?

In Italy, teachers show a degree of resistance when it comes to the use of technologies in maths teaching…
Only a few of them use technology.
GeoGebra is the most widely used tool in this sense.
The Ministry should be more determined when requiring the use of these tools, without stressing the importance of the exam only.

The attitudes of Italian students

- Students usually follow their teacher's attitude, even if they are slowly developing their own skills.
- If the teacher does not use these tools in his/her way of teaching, it will be quite difficult to find students who do this.
- As a consequence, many students do not use these tools during the state exams.
- At the most they use a scientific calculator (not a graphic one).

Some observations and judgements (and qualms…) of Italian teachers and students

- The TI-Nspire CX calculator is too expensive…
- Students prefer to use a CAS calculator in view of their future university choices…
- The calculator is not a winning option compared to smartphones and tablets…
- The interface is old and updated…
- Teachers prefer to use free apps such as GeoGebra or the ones they get in their smarphones.

List of the scientific and graphic calculators that can be used during the state exam in in Italy

See the last note dated 17th October 2018:
The five brand name calculators allowed during the exam are:
Casio, Citizen, HP, Sharp and Texas Instruments

A consideration: What does CAS mean?

In the TI-Nspire CX (non-CAS) calculator you can do symbolic calculations up to fractions.
In Texas calculators (not CAS) from computation with radicals onwards, calculation is considered symbolic.
But what does the Italian Ministry mean with the acronym non-CAS?

The Calculator and the exam

In Italy, the Ministry has not issued a specific legislation concerning the use of graphic calculators during the exam.
For example, the use of the calculator during the examination (Test mode) has not been regulated yet.

The attitude of Italian maths teachers

- Only a few of them use graphic calculators in class.
- Their use is not widespread.
- Teachers mostly use software tools, for example GeoGebra
- We cannot say that graphic calculators are fully integrated into teaching.
- Teachers usually implement the use of a textbook, but the idea of implementing the use of a graphic calculator is not common.

Assessment problems linked to the use of graphic calculators

- Teachers who use graphic calculators in their didactics say they have problems in evaluating their students' performances.
- They are inclined to grade with higher marks the students who do not use a graphic calculator.
- They fear that the use of a graphic calculator will make students lose their maths and reasoning skills.

Third part
Teacher training on TI graphic calculators in Italy

The T³ group in Italy and teachers' training

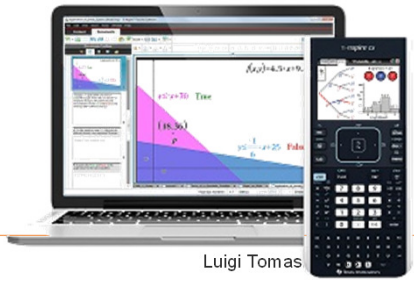
T³ - Teachers Teaching with Technology
Training teachers on TI - Texas Instruments technologies for the teaching of Mathematics
(STEM subjects - Science, Technology, Engineering and Mathematics)

Training managed by T³ Italy - Teachers Teaching with Technology

Starting January 1st, 2018 CampuStore Academy is partner of T3 Europe (Teachers Teaching with Technology), the Texas Instruments worldwide project for the training of teachers and educators on Texas Instruments technologies worldwide

Try the TI-Nspire ™ CX Teacher Software for one year https://education.ti.com/it/software

If you are a maths, physics or science teacher at a secondary school, request a free 1-year license for TI-Nspire ™ CX software for Teachers now, so you can try this technology at home in comfort. The activation codes will be sent to you by e-mail within 48 hours.
This interactive software allows teachers to present maths and scientific concepts to the class, demonstrate the use of the TI-Nspire ™ CX calculator and transfer documents.



Materials produced: a guide about graphic calculators published by DeA Scuola and Zanichelli sheets (which come together with the most common textbooks)

- Materials have been published (files, cards) linked to the most common textbooks in schools.
- In these cards there are maths activities for the first and second year (grade 11 and 12) and for the fifth year (grade 13) at Liceo scientifico. These are to be discussed in class using the graphing calculator (not CAS), in preparation for the exam.

Guide to the use of graphic calculators (published by DeA Scuola – Petrini)

Thanks for your attention!

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