

GRAPHIC CALCULATORS IN THE CLASSROOM: STUDENTS' VIEWPOINTS¹

João Pedro da Ponte
Ana Paula Canavarro
University of Lisbon

This paper presents the results of a study about the views and attitudes of students of a low achieving 11th grade class who were involved in an innovative experience with graphic calculators for all academic year. Contrasting the results obtained from a questionnaire and from interviews, it concludes that students tended to point some improvements in the mathematics class, but attributed their origin more to their teacher's style and personality than to the use of this technology.

Graphic calculators are a quite powerful new technology for mathematics teaching (Demana & Waits, 1990). They have obvious curricular implications, especially at high school and college level. They point towards significant content changes, emphasizing graphical representations, stressing issues such as units and scale; and they may even favor a shift in learning styles, with more exploration and student activity. This paper presents a study that investigated students' views and attitudes towards graphic calculators as well as mathematics classes and its effects in their personal relation with this subject.

Theoretical background

The general conceptions, views and attitudes of the students regarding mathematics and mathematics classes are increasingly seen as crucial factors affecting their performance (Schoenfeld, 1989). It is of great interest to know how much can these be addressed by curriculum innovations. In a recent experience of a new national curriculum, 7th grade students' views and attitudes were found to improve significantly, in close relation with the introduced methodological changes. However, in the same experience, the views' and attitudes of college-bound 10th graders showed no positive change, but rather an increase in anxiety and distrust regarding the system (Ponte et al., 1992).

Students' response to innovations in mathematics teaching is not always what the innovators seek. With powerful technologies, the students' approach to mathematics tasks may differ significantly, in an impoverished or even counterproductive way, from the original intentions (Hillel, 1992). And also, students' agendas and personal expectations regarding mathematics classes may resist to what they perceive as departures from the usual, and, on their view productive learning activities (Ponte & Carreira, 1992).

¹ Ponte, J. P., & Canavarro, A. P. (1993). Graphic calculators in the classroom: Students' viewpoints. *Proceedings of the XVII International Conference for the Psychology of Mathematics Education* (PME) (Vol. II, pp. 33-40), Tsukuba, Japan. This paper reports some results from the project "Dynamics of Curriculum Innovations", supported by JNICT (Portugal) under the contract PCTS/C/ECT/12-90. Also in this project are H. Guimarães, L. Leal and A. Silva.

Ruthven (1990) studied the effects on the performance of advanced upper secondary school students of extended use of graphing calculators. He reports that this technology had a strong influence both on the mathematical attainment and on students' approaches to specific tasks, especially what he called symbolization items. However, one should also consider the effects of such technologies in students' general views regarding mathematics learning. These views are closely related to cultural factors, as suggested by Vygotsky's (1978) approach to the study of social cognition. Their role should be considered to understand, and possibly influence, students' behavior in class (Schoenfeld, 1992).

The experience with graphic calculators

This experience took place in a suburban school not very far from Lisbon. The mathematics teacher has some tradition in using calculators. She participated in 1989/90 in a year long inservice program focusing in technology. In the following year she used graphic calculators with a 11th grade class. In 1991/92, she also used this instrument with a new 11th grade class, adding some new activities to those previously developed. She stated the following intentions for this experience:

Regarding the students: develop the intuition, establish connections between analytical and intuitive reasoning, show the students the importance of discovery, stimulate self-confidence, promote investigations and formulation of conjectures, develop the ability to formulate problems, develop communication and argumentation skills.

Regarding the class: change the climate, centering the class in the student and not in the teacher, adjust the technology used in class to the technology used out of school.

Regarding the curriculum: establish connections among different topics, usually viewed as compartmented, deepening the study of mathematical functions.

The class begun with 18 students but ended the school year with just 15. They were regarded as the weakest 11th grade class of this school, with a quite low achievement in mathematics (and in other subjects) and frequent behavior problems. In the beginning of the year the students were loaned a graphic calculator by the mathematics teacher, that they took home to use in their homework assignments and were supposed to always bring to class. They were also given an hand-out with the instructions to produce graphs of functions in the calculators. These were used in class in two ways: (a) to work on specifically designed activities, proposed in worksheets, generally to be carried out in groups of four; (b) occasionally, during the remaining mathematics classes, in an individual basis. The calculators were also used freely in tests. Some of the activities were intended to promote investigation, observation and discovery, exploring the graphical representations (Questions 1 and 2). Others were standard exercises that could be made both with the calculator or using the classical analytical approach (Question 3).

1. The figure represents the graph of the function

$$y = (ax+b)/(x+c) \quad (a, b \text{ and } c \text{ are real numbers})$$

Find the values of $a, b \in \mathbb{R}$. Explain your thinking.

2. a) Draw the graphs of the functions:

$$f(x) = x^2, g(x) = x^2 + 2 \text{ e } h(x) = x^2 - 1$$

b) Compare the functions in what concerns their domain, range, zeros and monotony.

c) How should be the graph of $y = x^2 + k$ ($k \in \mathbb{R}$)?

3. Draw the graph of $g(x) = |x| + 2$.

Study its domain, range, zeros, sign and monotony.

The classroom climate was informal and relaxed. But most of the students were frequently not much attentive in class and had difficulty in getting really involved in working in the proposed activities. By the middle of the year several of the students were no longer bringing their calculator to the class, as initially agreed.

Method

This study is part of a larger investigation dealing with two innovative activities, initiated by the teachers of this secondary school. Information has been gathered by a variety of ways, including classroom observations, interviews with teachers and students, and documental analysis. The data reported in this paper came from two main sources. One is a questionnaire made by the teacher to ascertain the opinion of the students about the work with the calculator that was responded in class by the end of the school year. It was a free-response instrument containing seven questions dealing with the use of the calculator and its implications in mathematics learning (see Figure 1). Another data source is the interviews made with three students. We wanted them to provide a variety of cases: one student interested in mathematics but with a weak reaction to the calculator, another not much involved with mathematics but adept of the calculator, and a third one interested in mathematics and frequent user of the calculator. Among these there should be boys and girls. These interviews lasted for about 45 minutes each, were audio-taped and transcribed. Analysis of the questionnaire responses and the interviews were made by the technique of "content analysis", following the main categories: (a) views of calculator, (b) view of mathematics classes, (c) personal relation with mathematics. We choose to contrast the results provided by these two instruments because we felt they would be most informative about the issues proposed for this study.

Results from the questionnaire

The responses that 12 students gave to the questionnaire are summarized in Figure 2.

Figure 1 – The questionnaire

1. In the beginning of the school year you were loaned a graphic calculator. Did you use it frequently or not? If not, explain why; if you used it a lot explain in what situations and disciplines.
2. Did the use of the calculator helped you to better understand any particular concept? If yes, which one?
3. Do you prefer using the calculator just by yourself or with other colleagues?
4. What seem to you the advantages and disadvantages of using the calculator in mathematics classes?
5. Do you think that the use of the calculator contributed to changes in the role of the teacher in the classroom, as well as in her relationship with the students? In what way?
6. Did the use of the calculator contributed in any way to alter your view of mathematics?
7. Give your opinion about the positive and negative aspects of this year's mathematics classes.

Figure 2 – Results of the questionnaire

Questions		Responses	
1.	Frequently 10	Average 1	A little 1
2.	Yes 10	May be 1	No 1
3.	In group 4		Individually 8
4.	Just advantages 6	More advantages than disadvantages 1	As much advantages as disadvantages 5
5.	Perceived some changes 8	No changes perceived 3	No answer 1
6.	Yes 8	Partially 1	No 3
7.	Just positive aspects 8	Mostly positive aspects 2	No answer 2

Views about the calculator. Most of the students reported to use frequently the calculator in mathematics classes, especially to make graphs of functions. Four of them indicated that the calculator favoured a more global understanding of functions and another four spoke of the possibility of confirming the results obtained by analytical methods. They reported having

used the calculator both to solve exercises in class and to verify responses in tests. They also used the calculator in physics to perform calculations and to store formulae in memory (a facility they discovered themselves).

All the students identified advantages in the use of calculators in mathematics classes. Ten of them stressed the help in understanding mathematics concepts (such as monotony, zeros, asymptotes), six referred they could make graphs and computations faster, and two indicated the possibility of obtaining complex graphs. A half of the students referred as a disadvantage a single aspect: the eventual dependence from the calculator with a consequential “difficulty in thinking by our own mind” or “making graphs by hand”.

Views about mathematics classes. For students, the calculator had no significant influence in the mathematics class, although eight of them pointed some differences. Among these, three referred that the student-teacher relation was strengthened because the teacher had to support them using the machine; two thought that classes became more interesting and less monotonous than usual; and another girl pointed to different teaching style, with a more active participation from the students. The undertaken of Group work, that was made only with calculator worksheets, was viewed as positive just by four students who valued the possibility of interchanging ideas with their colleagues. It should be noted that, from the ten students that indicated positive aspects regarding the mathematics class, only two referred the use of the graphic calculator. The remaining ones referred to more general aspects such as the good relationship with the teacher, her availability to respond to their questions, the light and fun climate of the class, and their increased motivation. As negative aspects, one student just referred the behavior of their colleagues and the fact that not all the syllabus had been covered.

Relationship with mathematics. Three students indicated that the use of the calculator did not affect in any way their view of this subject, whereas nine indicated some changes. From these, five indicated that the calculator made the topic “less complex”, giving them some advantage over the students that do not use the machines, and three referred that they were enjoying mathematics better. These changes mostly concern the facility with mathematics and the personal relation with this subject. They do not point towards a different view of mathematics.

Results from the interviews

Susana. She was regarded by the teacher as a good student but not much interested by the calculator.

Views about the calculator. In fact, Susana was almost untouched by the activities with the graphic calculator. She indicated to have some curiosity in the beginning but never come to be a frequent user. On the one hand she had technical difficulties that she never overcame. On

the other hand, her private mathematics tutor indicated that she should do the mathematics questions by “paper and pencil”, “analytically” – and she felt more confident with this approach. She just used the calculator in the tests to make sure that her graphs were correct. Making graphs and computations faster is the single advantage that Susana identified in using the calculator in the study of mathematics. In contrast, she stresses two disadvantages: one is the imprecision and lack of rigor of the machine that “sometimes fails to provide the coordinates of the points that one is looking for”; another has to do with the habits of “dependence” that it promotes.

View about mathematics classes. Her view of the mathematics classes was not affected by the graphic calculator. This student is particularly sensitive to the attitude that she feels from her teachers, and this was the most important aspect that she mentioned in this year – she felt that the teacher was quite interested about their students and made efforts to help them learning mathematics. The single influence that she pointed concerning the use of the calculator come across from the group work – however, she mostly valued the interaction with her colleagues and not the use of the machine.

Relation with mathematics. Susana recovered this year the enjoyment with mathematics that she had in junior high school. In 10th grade, she did not well in this discipline, attributing the responsibility to her teacher who “did not explain well and was not much concerned with the students”. But this year Susana understood most of the subject matter, both in class and in her out-of-school tutoring. She valued this aspect as very important since for her mathematics is a discipline “that must be understood”, which “cannot just be studied for the tests”, requiring a continuous effort. Another idea that she hold concerning mathematics is related to rigor, as she speaks about “the need of the analytical determination of required points”. This idea is certainly associated to the fact that Susana found the graphic calculator insufficient in the study of functions.

Leopoldo. This student was indicated by the teacher as generally not interested in mathematics but with a good relationship with the calculator.

Views about the calculator. In the beginning of the year he learned to make the graphs in the machine, feeling confident in using it. He thought that the calculator was of good help in the study of functions. Having used it both in class and in the tests, he pointed as its main advantage the possibility of quickly making the graphs of functions and confirming the results obtained by analytical means. As a disadvantage, he pointed to an eventual dependence from the machine that he admitted to have developed.

View about mathematics classes. Leopoldo thought that the use of the calculator “has made classes more interesting”, since it was a different thing that break the usual “monotony”. But the great differences that he noted in the classes referred to the “way of teaching” the subject by the teacher, to the enjoyable climate, and to the group work. It is interesting to note that in

class Leopoldo seemed quite involved with the machine, but during the interview never referred spontaneously to this instrument.

Relation with mathematics. Mathematics never was Leopoldo favorite topic and with time his interest for it has been decreasing. He indicated that this is closely related to his difficulty in understanding the subject: “If one can understand, it is a nice discipline, it is interesting. But when one understands nothing, it is quite boring...”

Ana. This student was indicated by her teacher as very interested in the calculator.

Views about the calculator. During the interview Ana never mentioned the calculator, but when questioned about it she was quite positive: “It is very cute!” During the year she used frequently the machine in class and in tests, both to make graphs and computations. She thought that the graphic calculator facilitates the understanding of graphs, as well as the results obtained by analytical means. As a disadvantage, she also indicated the eventual “dependence” from the machine. She said that, without the machine she is just able to make “not too complex graphs”, what she regarded with some apprehension.

View about mathematics classes. She confessed a great dislike from classes in general, saying that studying “was quite boring”. Nevertheless, she said that this year she enjoyed mathematics classes, which she attributed to the teacher. On one hand she found her “marvelous”, given the relation established with the class. On another hand, she liked the teaching style, explaining, making exercises, responding to questions. She also enjoyed group activities. She did not point to any influence of the calculator in class.

Relation with mathematics. Mathematics is not a topic of high interest to Ana. She never got much involved with this discipline that “requires much out-of-class work” – which “is not among her priorities”. She identified a “theoretical” and a “practical” side in mathematics. For her, success in mathematics implied the regular practice of exercises: “In mathematics it is not enough to memorize for a couple of hours, you need to practice.” Her lack of study shows up in her results, that are sometimes acceptable and other times not. For this student, the calculator did not arose a different relation with mathematics.

Conclusion

It is quite salient the lack of interest of most of these students for mathematics. This is related to their general lack of interest for school and to the difficulties that they find in this subject. They tend to regard mathematics classes as quite monotonous. The rather homogeneous views concerning the disadvantages of the calculator may be explained by pressures coming from different sides – from other mathematics teachers, from their private tutors, even from some parents. The calculator was seen as an useful add-on, that quickly draws graphs

and enables confirmation of results obtained “analytically” by hand, but not as something that radically changed the nature of the work.

The calculator did not improve dramatically the global achievement of this class. It was not regarded by students as a major influence in their way of learning mathematics. But one should note the great importance that they ascribed to the relation with their teacher and the global appreciation of her efforts.

There is much in common between what the students said in the questionnaire and in the interviews about the advantages and disadvantages of the calculator and how they regard mathematics classes. However, if one looks carefully, there is a distinct flavor in the results coming from these two instruments. From the questionnaire, one gets the picture that the calculator was valued as a quite important addition to their mathematical work. From the interviews, one is struck by their lack of reference to the calculator, and to the stress that they put into the relation with the teacher. This subtle difference may be due to the different ways the questions were posed to them: the questionnaire focused mostly on the calculator whereas the interviews sought to provide students’ perspective about the whole mathematics class. (More data, concerning these and other students, will be provided at the meeting.)

References

- Demana, F. & B. Waits (1990). The Role of Technology in Teaching Mathematics. *Mathematics Teacher*, 83, 27-31.
- Hillel, J. (1992). The Computer as a Problem solving Tool; It Gets a Job Done, But Is It Always Appropriate? In J. P. Ponte et al. (Eds.), *Mathematical Problem Solving and New Information Technologies: Research in Contexts of Practice*. Berlin: Springer.
- Ponte, J., & S. Carreira (1992). Computer Spreadsheet and Investigative Activities: A Case Study of an Innovative Experience. In J. P. Ponte et al. (Eds.), *Mathematical Problem Solving and New Information Technologies: Research in Contexts of Practice*. Berlin: Springer.
- Ponte et al. (1992). Students’ Views and Attitudes Towards Mathematics Teaching and Learning: A Case Study of a Curriculum Experience. *Proceedings of PME 1992*, Durham, NH.
- Ruthven, K. (1990). The Influence of Graphic Calculator Use on Translation from Graphic to Symbolic Forms. *Educational Studies in Mathematics*, 21, 431-450.
- Schoenfeld, A. (1989). Explorations of Students’ Mathematical Beliefs and Behavior. *Journal for Research in Mathematics Education*, 20 (4), 338-355.
- Schoenfeld, A. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D. Grows (Ed.), *Handbook of Research on Mathematics Teaching and Learning*. New York: MacMillan.
- Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge: Harvard University Press.