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The students strategies in the course of task solving with using the graphic calculator

Introduction

We learn mathematics through solving tasks. The analysis of that process is fundamental to answer the questions like: "how to teach mathematics?" or "how to teach to solve tasks?". That issue has been up-to-date for years, no matter what kind of tools are applied to solve mathematical tasks. The appearance of graphing calculators in Polish schools has provoked a research on the factual student's learning process with the use of that tool, in order to recognize both its advantages and disadvantages as well as its role and place in the process of learning and teaching mathematics. This knowledge is essential before the graphic calculator is generally widespread and permanently included into that process.

The goal, organization and tools of the study

The goal of the study under discussion was to examine and describe the ways of students' applications of the graphing calculator when solving a certain group of tasks. The performance of that goal resulted from a search for the answers to the following questions:

1. In what purpose do the students use the graphic calculator when working on a task?
2. What are the students' strategies[1] in the course of task solving?
3. What mathematical activities does the graphic calculator provoke?

The study was conducted in 2003. The subjects of the study were grade one students of a high school (gimnazjum) in Bielsko- Biała, where a program and a course book "Matematyka w gimnazjum z kalkulatorem graficznym I komputerem" (Kąkol, Wołodźko,2002) were being performed. The study took place during the accomplishment of the "Functions" section. Students' work during a lesson was observed (eight students on average were observed at every lesson), as well as four students who were observed during 45-minute extra classes for the period of four months.

The main research tool was a unique calculator program[2] enabling the records of the work being performed on the calculator. The program made it possible to record the work of each of the examined students, taking part in both regular lessons and individual extra classes. It is essential that the

[1] By a strategy we mean a conscious style of student procedures with the use of the graphical calculator, aiming at the solution to the task.

[2] The program was created at the Plymouth University

recording program allows to replay succeeding screen views of the calculator in a form of an accelerated film, as well as it allows to review the list of the bottoms pressed by the student.

The analysis of student's work

The application of the calculator recording program enabled a thorough investigation and an exact[3] reconstruction of the student's work performance when solving a task, with the use of a graphing calculator.

Task

For which "a" values the graphs of the f(x)=ax function will be perpendicular? Can they be parallel?

Remarks

The student, after learning the content of the task, starts looking for an example that would fulfill the requirements of the task. In order to achieve this, he compares the mutual position of the straight lines in the coordinate system, he concludes empirically. The student soon found an exceptional case y = x and y = -x, fulfilling the condition of the task This contributed to stating a hypothesis " the function slope coefficients must be opposite numbers". Making a few graphs with the use of the calculator caused the student to refute this assumption. The next stage of the work is finding the idea to solve the problem. To achieve this the student observed the graphs of the functions y = x and y = -x. The student performed a series of conclusions. He noticed that since the straight lines are perpendicular, they constitute four right angles. So one of the straight lines is the result of the rotation of the other straight line by an angle of 90° in relation to the origin of coordinates. So it is possible to find the image of any point belonging to one of the straight lines on the demanded straight line. In this way the student was looking for a formula of the line perpendicular to the graph of the function y = 2x. Finding this one, as well as other pairs of functions whose graphs are mutually perpendicular, enabled the student to formulate a general rule.

The student performed 13 trials. He found four examples of the pairs of functions whose graphs are mutually perpendicular. Finding the solution to the problem does not finish the student's work. Janek notices and formulates a new problem. The student answer was: The a coefficient of the second function must be a number opposite to the converse number of the a coefficient of the first function.

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[3] An every step of the pupil's work was supplied documentary evidence by indication chosen by pupil of function of calculator with description of aim of their utilization.

The analysis of full course of work pupil on the task permits to affirm, that the student applied two working strategies:
1) *establishing the value of a parameter*, that is achieving the result through defining and setting values to the measures given in the task as the variables, as well as
2) *analyzing the graphical model*, that is achieving the result through gaining information from the given graphical model, which is preceded by examining a given graphical representation.

In aim of comparison of process work all students solving this task and applied by them the strategies of work, we let's look on a scheme[4] – students' procedure paths – the application of the calculator, in which are contained the results of observation of students work.

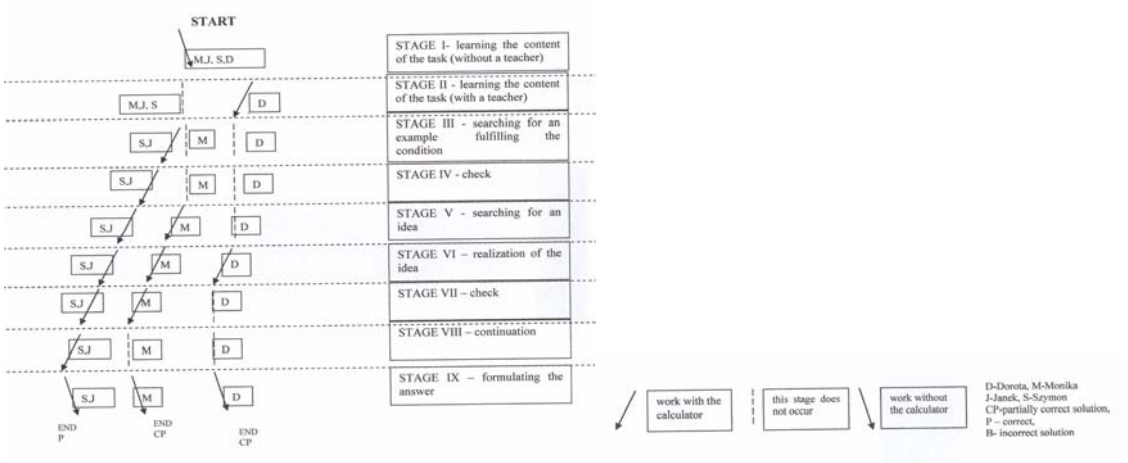

Fig. An example of a scheme – students' procedure paths – the application of the calculator

Students S And M applied the strategies of work called "**assigning the value of a parameter".** But during the student's D work, no strategy was not affirmed. This work depended on accidental, chaotic trials only. Despite this their observation permitted students at last to get partly correct answer (We by partly correct solution understand both full solution with mistakes, incomplete correct and incomplete with mistakes).

The example shows that the calculator with a recording program makes it possible to follow the student's activities thoroughly. The sequence of these

[4] The stages of the students' work revealed on the chart were specified and named as the result of the observation and analysis of calculator recordings and the students' work cards. The direction of the arrow slopes informs if a student used the calculator at that particular stage of work on the task. The work path of each student ends with the information about the final results of his work.

activities constitutes the manifestation of a certain strategy of the student's reasoning.

The above example shows that the graphing calculator with a recording program may be a tool enabling a thorough observation. It allows to follow the factual student's process on the task, and not to be content with a mere analysis of a student's work results, that is on the filled work cards. The graphing calculator with a recording program made it possible to observe the similarities and differences of the students' working strategies when solving the same task. In the study, the recording program supplemented with the analysis of working cards and a discussion with a student allowed to create substantial registers of both the goals, for which this tool was applied by the students, task solving strategies, and mathematical activities triggered by the application of the calculator[5]. This allows a statement, that the graphic calculator may play a positive role in the process of mathematical education, favor the development of a student's mathematical activity and creation of his own mathematics. The application of this didactic vehicle, as well as others, apart from its advantages, has disadvantages, too. The application of the recording program allowed me to observe the threats and limitations resulting from working with this tool. Learning them will definitely allow to eliminate some of the negative effects of the calculator applications.

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[5] The study results are presented in a doctor's dissertation.