How graphing calculators build deep understanding: what one study says.

Research Note 5

Rivera, F.D. (2007), Accounting for Students Schemes in the Development of a Graphical Process for Solving Polynomial Inequalities in Instrumented Activity. *Educational Studies in Mathematics.*

How graphing calculators build deep understanding: what one study says.

Research Note 5

In an ethnographic study of TI-89 use in a Precalculus class, the device played an important, mediating role in the progressive evolution of mathematical thought, from the concrete to the abstract, or from material to theoretical knowledge. This study provides a detailed account of how deep conceptual understanding can build through use of a graphing calculator.

[The following is excerpted and adapted from the full paper – ed.]

Consistent with Vygotsky's view that individuals' (inter)actions with their environment are not directly experienced but are oftentimes mediated, most mathematical concepts and processes that learners seek to appropriate are not readily and superficially evident to them. Furthermore, while tools are externally oriented, they are also capable of influencing learners' thinking about concepts and processes that are being targeted for acquisition. Such tools assist learners to exercise control over mental functions that influence their thinking. In Vygotskian terms, [handheld graphing calculators] mediate as *psychological tools* between the learners' minds and required sociocultural acts of mathematizing.

Method. In a series of narratives, the teacher-researcher provides an account of how his students developed a graphical process for solving polynomial inequalities over the course of twenty-one 55-minute classroom sessions, through use of the graphing calculator. In this Precalculus class there were 13 males and 17 females consisting of juniors and seniors (mean age: 16.63; 26 Asians and Asian Americans, 4 Hispanic- Americans). The researcher taught the class while the resident teacher observed and took down notes throughout the study.

When the students were asked to explore problem tasks, they would work in pairs first and then a plenary discussion would take place. The problem tasks were usually stated in an open-ended format so that it was possible for them to generate their own responses. The researcher kept a record for himself and especially wrote detailed accounts in cases when an important issue came up during a classroom session. Further, because he was not allowed to either audiotape or videotape any classroom session, he wrote the transcripts of important conversations during, when it was possible to do so, or immediately after class time. All the students' work (homework assignments, worksheet responses, and tests) was collected for this investigation. After every session, the resident teacher and the author would debrief and share what each of them thought was interesting and worth considering for analysis. Extensive examples of the student discourse are included in the full paper.

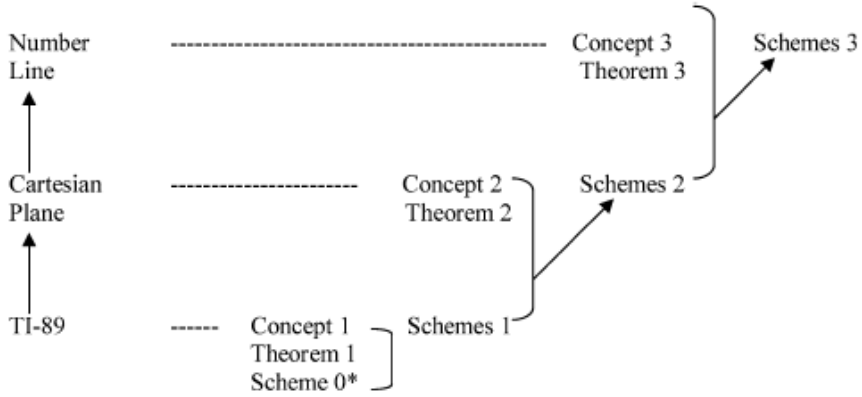
Conclusions. Observations led to the conclusion that students went through stages of refinement of their concepts- and theorems in action. These are summarized in the table below:

Concepts- and theorems-in-action at each refinement stage in the instrumentation phase

Tool	Concepts-in-action	Theorems-in-action
TI-89	Graphing a polynomial function; using the y-editor screen to enter the function; setting the appropriate window range in order to obtain a correct full view of the corresponding graph	End behaviors of graphs of polynomial functions; patterns of even- and odd-powered polynomial functions
Cartesian plane	Setting up coordinate axes on paper and computing for points in order to draw an accurate graph	Evaluating polynomial functions; remainder and factor theorems
Number line	Drawing a rough sketch of the graph with only the zeros	Bounds in an interval notation as consisting of the zeros of a polynomial function

Rivera, F.D. (2007), Accounting for Students Schemes in the Development of a Graphical Process for Solving Polynomial Inequalities in Instrumented Activity. *Educational Studies in Mathematics*

The stages evolved using this chain:



Among the researcher's conclusions is that the evidence confirms that "…Learners use tools to organize their behaviors and actions around situations that pertain to a targeted object of knowledge. Tools become efficient and meaningful only when social circumstances allow them to develop appropriate representations, practices, and language."

Reference:

Rivera, F.D. (2007), Accounting for Students Schemes in the Development of a Graphical Process for Solving Polynomial Inequalities in Instrumented Activity. *Educational Studies in Mathematics.* Downloaded from Online First, January, 2007.