Summary of the Technology Working Group: Examples, Issues, Next Steps

Final summary submitted by
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This Working Group explored appropriate application of various forms of technology for a range of grade levels from primary school through college. Our discussion included appropriate use of calculators; various software programs (some dedicated to mathematics, and others that are otherwise mathematics-friendly); and the delivery of coursework or mathematical experiences online. The content or contextual situations embodying the use of these technologies were weighed against the cognitive and pedagogical fidelity of the intended learning experiences.

For mathematical experiences involving the younger students we explored the power of building number sense via technology, and the importance of knowing the mathematics concepts sufficiently to better judge the appropriateness of solutions obtained when technology provides the calculations. The majority of the technology examples for younger students featured the use of calculators with options that support a broad range of mathematical explorations (e.g., numerical computations, review of measurement equivalencies, generalization of numerical patterns, data analysis, probability, geometric explorations). Two computer software examples were explored. Autograph software supported the analysis of real-world data (imported from the internet or other external files) and student-collected data in multiple representations. Computer and hand-held electronic game software (teacher-designed or commercially available) were highlighted to discuss the power of providing learning experiences paired with fun and games.

For mathematical experiences in the high school and university years, we explored the power of multiple representations while engaging in explorations of algebra, geometry, or calculus; the use of websites for supporting discourse among users who are engaged in various levels of mathematical learning communities; and options for delivery of coursework via online and hybrid (online, plus face-to-face) alternatives. We explored tips on maximizing the mathematical use of Microsoft *Office* software; and tips for gaining access to various software (e.g., *NetLogo, Ubiquitous Presenter, POV Ray, MessageGrid,* virtual manipulatives) and equipment (Hewlett-Packard Tablet PCs) free or via competitive grants. [For more specific highlights see below.]

The group discussed the degree to which the use of calculators is promoted and realized in schools. In Norway, calculator use has been promoted since the 1990s. In England, calculator use has been promoted; yet for some examinations and tasks, they are not permitted. In America, in spite of the promotion of the efficient use and availability of calculators, there is no consistency across or within the USA. In upper secondary in Norway, the government is now encouraging the use of laptops. The first examinations will be offered at the end of this school year—by hand for the first hour, and use of any type of technology in the second hour. It appears that students prefer to have calculators during the exam, even if they are not using them. As we look ahead to the use of computers in the classroom, teachers have not received special training for using them.

When the graphing calculators were introduced in Norway in 1994, teachers did not have the necessary training. However, since students were told they would need the calculator for the exam, the teachers responded by getting prepared to teach with them.

Part of the problem, as we discussed it, is that education tends to move at a glacial rate of change, while the use of calculators and other technology is moving much more quickly. We have handheld tools that now have as much power as computers had a generation ago, yet over that time period there has not been a sufficient or comparable change in the schools. In earlier years we had rapid and drastic changes, but in the last five years there are actually fewer major changes. Perhaps we are moving to more stability; yet more time is still needed to convince teachers to get on board. We discussed the Wittenberg Project in Germany. About 8%-10% of the students in the high school use *Maple* software, but they could also perform those calculations with the ClassPad calculator. There was a question regarding the use of these tools on the major exams. Now some of the items that were assessed on exams can be handled by simply pushing buttons on a calculator. Classes that were able to use *Maple* had different types of questions such as modeling tasks, while those who did not have computer access were given other types of questions. An indication of a need for more teacher training for use of technology in learning was the significantly lower grades on the exams for those who had been using *Maple.* There had not been sufficient class time devoted to the thinking processes necessary to respond to those types of questions.

On a national exam in the USA, we have advanced placement (AP) exams. In calculus the exam has four parts: two with calculator, and two without. One part is multiple-choice, and the other is free-response (3 problems). So the exam has changed over the years to adapt to the type of handheld technology that students can bring, including calculators that have CAS. The types of questions that are asked when technology is permitted would be those questions for which the technology can only help if students know how to perform the mathematical calculations. For example, problems like generating a Taylor series would be on the part of the test for which the calculator would not be permitted.

Do we need a change in content? Do we need to spend time training students to solve problems that can now be solved by machines? These are important questions for us to answer in the next years.

Below are some specific statements to highlight major points explored during the conference.

- Use of calculators
    - Calculator for Elementary School Students
        - Know the calculator you are using: You may perform operations and get unintended results!
        - Use calculators powerfully to build number sense more than to simply perform calculations.
    - Calculator for Middle School Students (TI-73)

        - Teacher support and student learning activities are available at www.education.it.com.
        - Using the APPS menu we explored activities supporting the learning of angles (measurement and estimation of measurement); a version of LOGO (e.g., LOGO LIGHT), which permits some exploration of interior and exterior angles of geometric shapes; and electronic geoboard software for exploration of Pick's Theorem.
    - ClassPad300 or ClassPad Manager
        - This calculator supports exploration of multiple representations via its split-screen window option and the interactive connectedness of being able to drag content in one window (in one representation) to another window to see a new representation.
        - Specific mathematics content we explored included interactive geometry, solving linear differential equations, and solving definite integrals for natural logarithms and trigonometric equations.
- Specific Technological Equipment
    - Tablet PCs
        - Each student in possession of a laptop can ink in his/her answers to a posed problem, and the results can be made available to the entire class or only to the teacher.
        - Two free software programs serve as utilities that enable students' inked answers to be made available to all: *Ubitquitous Presenter* (San Diego; contact up.ucsd.edu) and *MessageGrid* (contact Dr. Pargas at pargas@clemson.edu).
            - The teacher can highlight areas on a students' response and use that students' work as the context for follow-up discussion.
            - Images can also be made available.
        - Hewlett Packard has an annual offer which permits college profs to apply to get 25 tablet PCs for their classes—must submit a detailed proposal to identify what will be done with them. A second year option permits the possibility of 42 additional tablet PCs, if successful during the first year.

- Delivery systems for courses
    - Online courses
        - Complete degree offered online through Western Governor's University (USA) by having a competency-based program.
        - Content may be delivered from external sources, and students take competency exams to document their learning.
        - Program has achieved national accreditation in the USA
    - Hybrid online-face-to-face courses
        - Online portion should facilitate exploration and learning
        - Should help learners identify and connect their previous learning to this new learning
        - Some textbooks also provide online support and online learning

        - Issues to address involve communication (e.g., the amount and kind of face-to-face support as well as online support); frequency of contact; assessment (e.g., orientation quizzes, online homework, quizzes, tests); the teacher's role
- Exploration of Specific Programs, Web-based Resources or Electronic Projects
    - Autograph
        - We are able to import and export data, perform various operations on the data and provide multiple representations of the data in various graphic models as appropriate.
    - Microsoft Office 2007
        - Features that are new or different than earlier version
            - Superscript is now on the main page: you may see x^2, but there are other superscript options there as well.
            - INSERT menu has all the things you could possibly insert.
            - DRAWING tools menu now available near upper-right hand corner of screen of main page. Many more shapes now available.
                - SHIFT before you let go of mouse will give you the regular polygonal shape, and also creates the shapes from the center rather than from a corner.
                - To get a straight line, select the straight line/line segment tool, but press SHIFT
                - To ADD TEXT to a drawing (more complicated than before) you can select INSERT dummy-text, then clear that text and type yours inside.
                    - You can right click over a drawing object and add text now (more easily than before)
            - SNAP to a grid is now less easily located. To find the GRID (in a counter-intuitive way) use the BRING TO FRONT submenu.
            - If you want to ROTATE a composite object, wait for the four-arrow cursor to appear, and then rotate.
            - SELECT OBJECTS is now under the EDITING menu. Right click with PC; CTRL click with Mac.
            - Making graph paper is now quite handy using CTRL Z and CTRL D as needed.
            - Placing text around, to the side/above/below an object, "go to the dogs" icons that will help you choose the style you wish. If you select "tight" then the text will fit in tightly around the object depending upon where you move it.
            - Many of the mathematical symbols you want can now be located within the FONT, when you use INSERT symbol and see {normal text}. If you go to the SYMBOL font then this font may not type out when printed, because it may not be available in the font style you've chosen.
            - You may locate the Character Map and insert the symbols you wish to have for your default operations in MS Office 2007.

        - INSERT equation is not the same as MS Equation 3.0.
        - Whenever you save a file, you should use the SAVE AS command and choose MS version 97, 2003, etc., because none of those older versions can read MS Office 2007.
    - Features present in both old and new version
        - CTRL up (arrow) and down (arrow) permits zoom in and out.
        - Previously we could double-click on something, and we could get repetition of the previous command. This is no longer available in MS Office 2007
        - CTRL and drag is another way of duplicating an object
        - CTRL D helps to duplicate an item. The usual duplication mode of MS Office is to place the duplicate object two steps over and two steps down from the original. You may now "train" MS Office to provide the duplicate in the direction you indicate by modeling it first.
- *POV Ray*, *MuPad*, etc.
    - Ask dynamic questions which help students to see the power of parametric equations.
- CASMI Project
    - This interactive, membership ONLY, website allows student members to send in solutions to website-posed problems and then get feedback on their solutions by graders who are either preservice teachers enrolled in various courses, or paid student workers (often previous preservice teachers who did this during their college courses).
- NCTM (E-Resources, Illuminations), Shodor, National Library of Virtual Manipulatives, other websites
    - These sources are available to the public and provide applets, virtual manipulatives, and other resources that can be used by the teacher and students.
    - Cornell University's Pendulum Balancer
- *NetLogo* (google for a free download of this software from the Northwestern University, USA)
    - We are reminded to design or select mathematical modeling examples that will entertain higher levels of cognitive (i.e., students actually doing mathematics), and for the content, pedagogical, and cognitive fidelity issues to remain faithful to the mathematics content we are trying to help students to learn
    - Use of *Hubnet Client* software, with *NetLogo* and the TI-Navigator calculator network system was described as a means of engaging a class in an interactive experience with a mathematical model.