Working Group: Developing Comprehensive Open-Source Geometry Curricula using GeoGebra

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Abstract. Imagine combining the best characteristics of your favorite new geometry textbook with GeoGebraTube. It would cover all the material required for your ideal version of a full course on geometry, easily accessible and usable by teachers and students. However, it would also be free, flexible, up-to-date, easily revised and downloadable as needed by teachers and students. It would include activities tested in diverse classrooms, reviewed by teachers and flexibly adaptable to different languages, cultures or pedagogical preferences. Perhaps most importantly, it would take full advantage of GeoGebra for a dynamic, hands-on, visual, drag-able, constructible, personalizable exploratory-learning approach to geometry. The currently missing piece for moving GeoGebra into the center of contemporary mathematics education is the availability of comprehensive curriculum aligned with standards. GeoGebraTube provides a medium for shared resources, but requires coordinated efforts to develop model curricula and an interface for flexible, collaborative usage.

Themes. Curriculum, CSCL Environments, Practices, Technologies.

Keywords. Curriculum Development, Collaborative Learning, Common Core, GeoGebraTube, GeoGebraBook, Open Source, Search and Browsing Software.

Working Group Goal

The goal of this working group is to stimulate development of comprehensive geometry curriculum centered on student use of GeoGebra. This will support the use of GeoGebra by geometry teachers around the world by helping them to integrate student use of GeoGebra into their classroom activities, enhancing the pedagogy. This working group is only intended to start the process. Perhaps it will stimulate people thinking seriously and strategically about possible approaches and put them in contact to pursue next steps. Success with basic geometry could provide a model for other areas of mathematics.

Problem Statement

While some new textbooks and the US Common Core standards recommend use of dynamic-geometry environments to "provide students with experimental and modeling tools that allow them to investigate geometric phenomena," they put the burden on the teacher of realizing this in the classroom. However, curriculum development and the construction of the corresponding well-designed GeoGebra files is a sophisticated and time-consuming task. Teachers have neither the time nor the resources to do this on their own for a whole course on geometry. They need well worked out curricula that they can choose from and adapt to their local needs.

Curricular items are currently made available through GeoGebraTube. However, that software does not support the assemblage of comprehensive, well-organized and easily adapted curricula. Nor does it support collaborative usage by student teams. GeoGebraBook can be a first step, but more is needed.

Curriculum in GeoGebraTube is currently unorganized; it is not systematic or comprehensive; it is not tied to progressive pedagogies. The consequence of this is a serious under-utilization of the potential

of GeoGebra in typical classrooms. Without well-tested tutorials and curricula for important topics like construction, proof or custom-tool programming, teachers tend to fall back on using GeoGebra for fancy visualizations, and students use it to create pretty pictures. The power of dynamic geometry to stimulate mathematical thinking and cognitive development of students is barely touched.

Working Group Focus

This working group will focus on enumerating the major issues and the main tasks that need to be addressed initially. The central question is how to support the integration of GeoGebra into geometry courses around the world. This includes approaches to both collaborative learning in small groups and individual learning. A particular opportunity of the Internet-based single-user and multi-user versions of GeoGebra is their use by online schools and for networking home-schooled students or students in countries with dispersed populations. Although intended to be useful for students world-wide, the curriculum might be aligned with the US Common Core standards as a framework. Although it is not necessary that GeoGebra be used for every aspect of school geometry or other math courses, the target curriculum should support a strategic, systematic approach to the aspects that it does address.

Background Information

The Virtual Math Teams (VMT) Project (2003-2014) developed an online environment for collaborative dynamic geometry using a multi-user version of GeoGebra and text chat. (Stahl, 2006; 2009; 2013). It developed an associated mini-curriculum focused on collaborative learning of construction of geometric dependencies. This curriculum has been tested and revised each year. A version is now available as a GeoGebraBook (Stahl, 2015); it focuses on developing an understanding of how to construct geometric dependencies based on the beginning of Euclid's *Elements* and explores many notions recommended by the Common Core for middle school. This active book lets students work on 50 individual challenges in GeoGebra. Unfortunately, it is not multi-user, it is not persistent, there is no chat and it is not instrumented for researcher analysis, student learning analytics or teacher supervision.

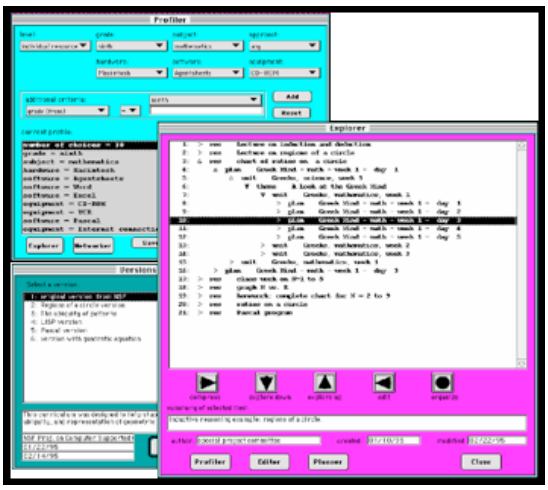
An earlier project, the Teachers Curriculum Assistant (TCA) designed in 1994, explored the possibility of searching and browsing a database of curricular materials even before the Web existed (Stahl, 2006, Ch.1; Stahl, Sumner & Owen, 1995). It focused on five principles for a shared repository of constructivist educational resources, which could be applied to GeoGebraTube as follows:

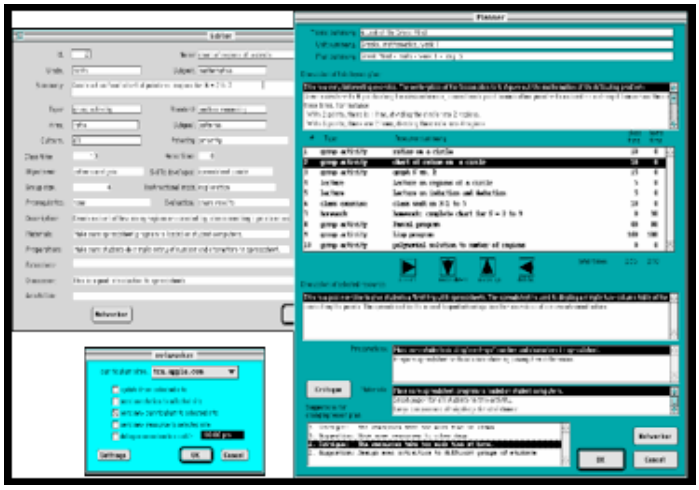
1. Carefully structured summaries (meta-data) of the resources must be defined (when they are uploaded) and maintained, to support search. (GeoGebraTube begins to do this.)
2. The search process should be supported through a combination of query and browsing tools that help teachers explore what is available. (GeoGebraTube provides a simple search.)
3. Adaptation of tools and resources to teachers and students is critical for developing and benefiting from constructivist curriculum. (GeoGebraTube allows editing, but not versioning.)
4. Resources must be organized into carefully designed curricular units to provide developmental learning sequences. (GeoGebraTube has tags and Books, which are a start for this.)
5. GeoGebraTube should be a medium for sharing and combining curriculum ideas, not just accessing them. (In GeoGebraTube, "sharing" is just sending a link through social media.)

The following components of TCA were designed: a Profiler, Explorer and Versions (see figure below on the left) as well as a Planner, Editor and Networker (on the right). They are suggestive of useful functionality. These allow curriculum developers and teachers around the world to search for resources, try them, edit, annotate and store new versions. They also facilitate the aggregation and structuring of coherent sequences of curricular resources into course modules adapted to local needs of specific countries, schools, teachers or students.

Individual curricular resources and coherent sequences of them can be linked to relevant pedagogical materials, such as instructional models, logs of student usage, experience reports,

pedagogical recommendations, ratings and reviews. This supports a broader conception of curriculum, including examples of pedagogical approaches, models of successful usage by teachers and students, discussion of alternative options, assessment instruments and research analyses.





A MOOC Model for Collaborative GeoGebra

Massive Open Online Courses (MOOCs) and sites like Khan Academy provide useful educational resources, but they generally involve passive watching of video lectures, rather than engaged social learning. The VMT approach suggests a collaborative model, integrated with local classrooms and teachers. GeoGebra Institutes can provide teacher professional development in the proposed curricula. Then teachers can adapt the curriculum to integrate with their courses. Teachers organize small groups of their students to work collaboratively on GeoGebra curriculum, motivating each session in advance, then sharing group findings in whole-class discussions. The teachers guide the exploratory-learning trajectory and manage the grading (with automated support from the software). This overcomes the problems of MOOCS, takes advantage of large-scale resources and supports local mathematics education.

Discussion Structure

The author team will begin by (a) motivating and illustrating the topic with the example of the VMT Project, its pedagogical approach to exploratory collaborative learning, and its sample GeoGebraBook curriculum. It will then (b) facilitate open discussion, starting with the questions and topics listed below. Finally, there will be (c) a wrap-up enumerating priorities, next steps and potential participants.

- How can comprehensive curriculum advance teaching and learning with GeoGebra?
- What new features should be designed into GeoGebraTube and GeoGebraBook to support meta-data, searching, browsing, adapting, annotating, reviewing, linking etc.?
- How should GeoGebra Institutes be involved? Should there be a form of MOOCs?
- Can curriculum be designed to support and assess both collaborative learning and individual learning?
- How can teachers be supported to adapt curricular units to their classrooms and how can they be involved in evolution of the materials?
- How can examples of teacher approaches, student work, assessment instruments, etc. be integrated into the materials?
- What resources are currently available and what further resources—such as research funding—should be sought?
- Who is interested in collaborating in further work on this?

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