

GeoGebra and STACK

Creating tasks with randomized interactive objects with the GeoGebraSTACK_HelperTool

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Abstract: This article describes possibilities how to use GeoGebra in STACK. The author developed a tool especially for STACK task creators for generating "GeoGebra in STACK" tasks. Download, instructions and samples how to use the HelperTool are available at:
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Download, instructions and samples how to use the HelperTool see above.²

A comfortable use of graphical elements in STACK tasks³ is a common issue of people creating them. Of course, there are possibilities to embed pictures (even randomized) and of course there are possibilities to use the standard plotter. JSXGraph (Gerhäuser, Miller, Valentin, Wassermann, & Wilfahrt, 2011)

adding interactive elements, too. However, for anything, but displaying pictures, experience is needed and to get done a good-looking, well working example, is rather complicated. Most of the times it is necessary to write or modify JavaScript-code (or JSXGraph-code).

For people that have some experience with GeoGebra the GeoGebraSTACK_HelperTool will help to realize projects more easily. It allows to use GeoGebra⁴ files in your STACK-question without having any other coding experience. Also there is a project-save-file to save and load a task. By using the save and load functionality manipulating of tasks is protected. Therefore, there is no risk of loosing any relevant Java-scripting parts by accident, so inexperienced student assistants can work on such questions too, even without STACK experience. Creating an applet can be easily separated in programming the STACK-part

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² Slides of a presentation with animated gif-pictures see: <https://www.stack-konferenz.de/wp-content/uploads/2018/12/Workshop-Geogebra-und-STACK-English-LUTZ.pptx>

Feel free to contact the author e. g. for feature requests, support requests or sample tasks.

³ About STACK: (Sangwin, 2013), ("STACK Demonstration site (v4.0.1)", n.d.), (Sangwin, n.d.)

⁴ For an overview of GeoGebra in mathematics education: see (Kaenders & Schmidt, 2014)

and in providing the ready-to-use GeoGebra JavaScript-code, generated by the HelperTool. All this is of great help for creating many tasks by mainly STACK inexperienced, but also for GeoGebra trained persons who work/study in the sector of mathematical education. Complex graphical construction built in GeoGebra by point, click and define operations are easy for GeoGebra users, programming equal JSXGraph-code is a rather demanding process, which fewer people are experienced in.

The GeoGebraSTACK_HelperTool takes a GeoGebra file and returns ready-to-use JavaScript-code to copy into your STACK-question (html-mode).

Therefore, a simplistic GUI asks for settings like dimensions, display ratio, features, GeoGebra-objects of interest and initialization commands (for graphically randomized tasks).

See figure 1 as example screenshot.

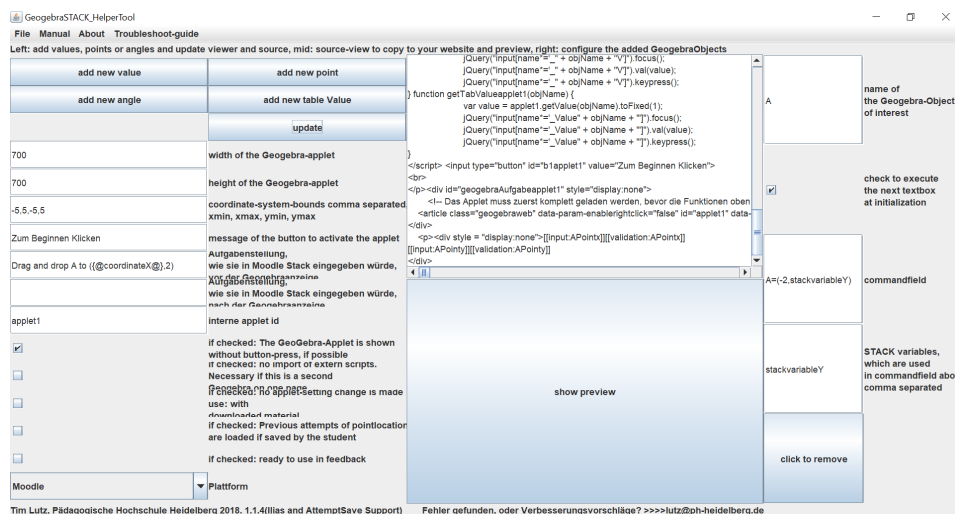


Fig. 1: Screenshot of the HelperTool. left columns: settings and control-buttons , right column: GeoGebra-object of interest: "point A", at the beginning point A is set to "(-2,stackvariableY)", where $stackvariableY$ is a predefined STACK-variable of "Question variables"

Supported are Ilias and Moodle (provided is an installation of STACK and JavaScript is "allowed" in html-editor).

Three examples of using GeoGebra in STACK ... from easy to complex

There are three main scenarios, which can illustrate the potential of using GeoGebra in STACK.

GeoGebra graphical applets for displaying geometric information:

It is possible to display any geometrical construction (like triangles, . . .). By fixing the corresponding points, the result will be static, by having them variable, let the students explore a construction. In addition, GeoGebra is a function-plotter you can utilize in your questions, just for viewing a static window or letting the students navigate or zoom in and out. Even Viewing non-mathematical content like animations of motors⁵ is possible. Any material, as e. g. created by yourself or found in a pool of already existing GeoGebra online resources, can be used (except high-definition image-content in a GeoGebra-task, which would result in huge files).

GeoGebra graphical applets for randomized graphics:

In STACK, question randomization is easy. However, graphical randomization is harder to achieve. For example, you could take pictures of all different graphical situations and just show them with the new block-mode by hand. If you want to graphically randomize your "GeoGebra in STACK" task it is rather easy (see figure 2 and 3). In a first step, (hidden) sliders in GeoGebra can be used to create different graphics as usual. The GeoGebraSTACK_HelperTool helps to use STACK variables to randomize the graphics by randomizing the value of the created sliders in a second step (explanations see manual).

GeoGebra graphical applets for interactive tasks:

It is possible to prepare a GeoGebra-applet where objects are interactive, see figure: 4 and 5). By using the HelperTool you will be able to tell STACK which point-coordinates or values you need to know from GeoGebra for evaluation.

One can combine all these three types to create more complex tasks.⁶

⁵ example: <https://www.geogebra.org/m/fmhfXxu9#material/fCHTsj4R> , by EDC in Maine

⁶ One could find even more scenarios to use GeoGebra in STACK, e. g. in student feedback to show a step-by-step solution with graphical support. (Example: question: " $(a + b)^2 =$ " ; student answer: " $a^2 + b^2$ "; in feedback: step-by-step solution, see <https://www.geogebra.org/m/HRqRgykt>)

If students should get feedback to a graphical interactive task, displaying a graphical solution to that task within feedback should be considered, see figure 6.

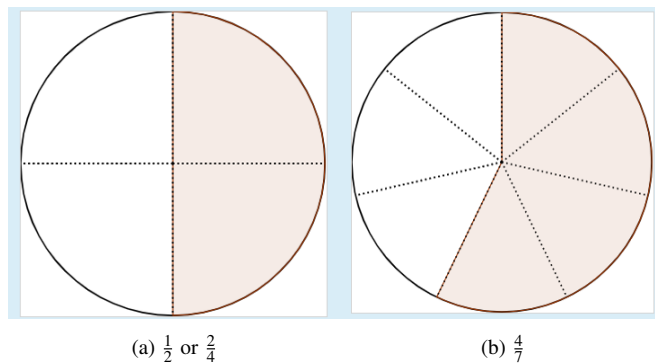


Fig. 2: Example of a graphically randomized task: What fraction is shown? (tasks from mathebruecke.pinkernell.online)

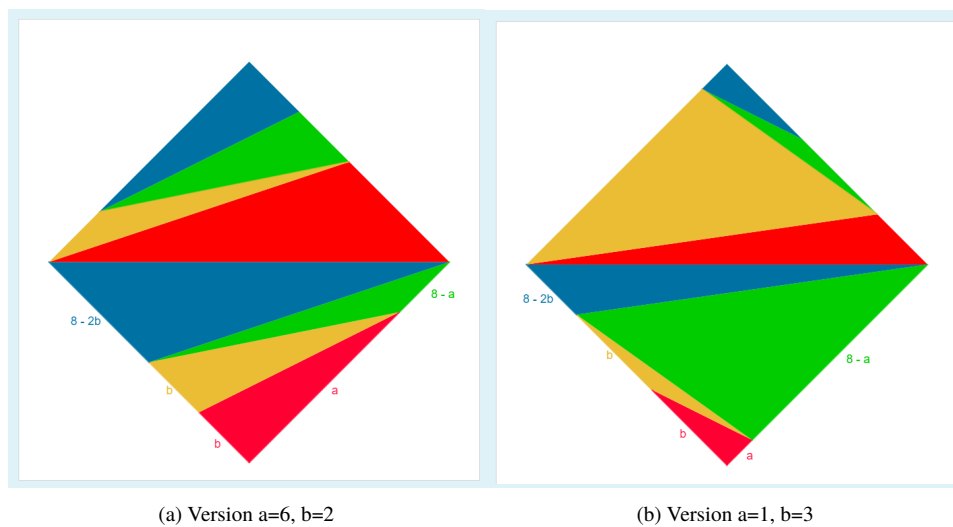


Fig. 3: Example of a graphically randomized task; idea by "Gymnasium Bensheim" inspired by Max Bill. (Similar tasks inspired by Richard Paul Lohse, see Brauner (2009))

Features

Common GeoGebra-objects that are available in the HelperTool are points, values/sliders, tablevalues (tableview). More object categories can be added if requested. Previous student answers can be reloaded like typed answers. This also works with "fill in correct responses". STACK input fields (hidden) which are generated by the HelperTool can be accessed as usual. (example, see: Listing 1 and figure 4)

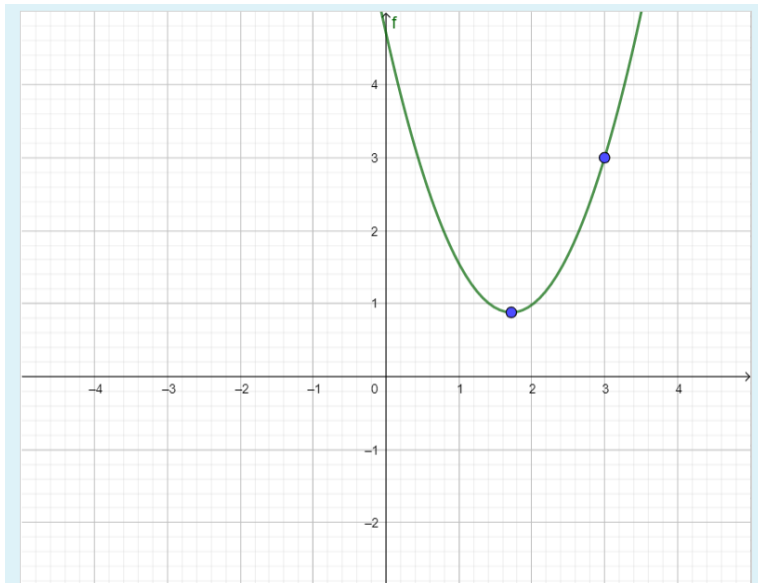


Fig. 4: Example of a randomized interactive task:
The student has to drag the points such that the given (randomized) function $f(x) = 2 - 2 \cdot x^2$ is drawn.

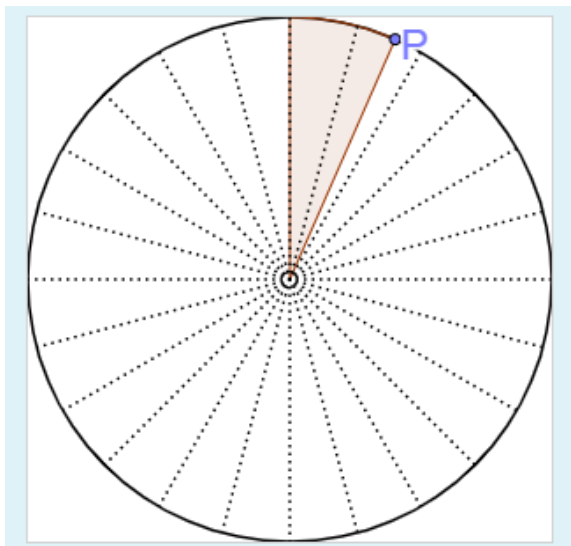


Fig. 5: Example of a simple randomized interactive applet: drag P, so $\frac{3}{4}$ (or an other randomized generated value) is marked.

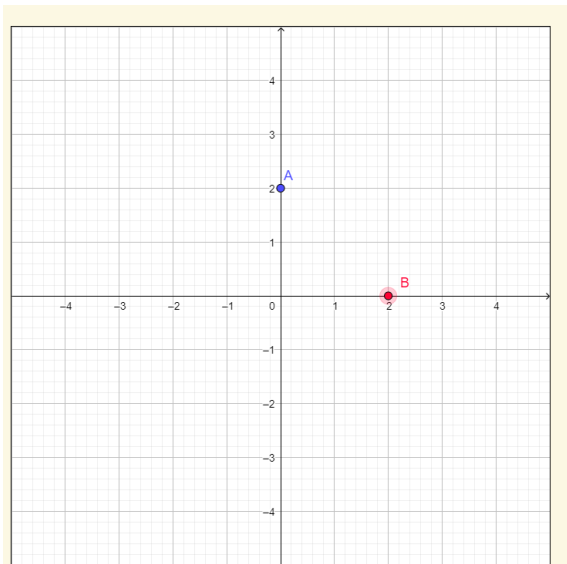


Fig. 6: Example of a minimalistic task "GeoGebra in STACKfeedback:
Displaying the (wrong) student solution and the correct answer as calculated by STACK

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punktlisteGeom : [[ BPointx , BPointy ] ,
 [ APointx , APointy ] , [ CPointx , CPointy ]]
n : length(punktlisteGeom);
Grad : n-1;
g(x) := x[2]
= sum(a[i]*x[1]^(n-i) , i , 1 , Grad)+a[n]
Gleichungen : map(g , punktlisteGeom);
Unbekannte : makelist(a[i] , i , 1 , n);
l : solve(Gleichungen , Unbekannte);
ansFunktion :
ev(Unbekannte . makelist(x^(n-i) , i , 1 , n) , l);

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List. 1: By the HelperTool generated objects can be used as usual, e. g. defining a quadratic function by 3 GeoGebra points in STACK/maxima (one point is hidden and dependent, because one point defines extremum)

A Feature which probably won't make it to the HelperTool:

The GeoGebra_HelperTool helps with working with known GeoGebra objects. With JavaScript experience, it is possible to dynamically create Geogebra objects like points in runtime, e. g. by clicking a button.⁷ It is also possible to log the new created objects and their information. This functionality has not made it to the HelperTool by now, because it is locally not necessary to make this specific use available for easy use by unexperienced task creators.

Features which would be desirable:

During the preview process a list of GeoGebra-objects of the ggb file is generated. It would be helpful to use that list to select the GeoGebra-objects of interest from the list of all GeoGebra-objects in existence. So there will not be an issue like “In GeoGebra this point is named different from the point in the HelperTool”. An automated preview hidden in the background to run the applet is necessary to perform such an improvement.

GeoGebra is a mighty but complex tool for students to work with. Reducing complexity by removing functionality (e. g. toolbars, forbid scrolling around) is a general design concept of the HelperTool. It is controversially discussed if reducing complexity is needed in the graphical user interface of IGS (interactive geometry software/DGS, see Schimpf and Spannagel (2011) or Mackrell (2011)). The HelperTool hides everything unnecessary by default. A next major step will be adding the functionality of easy construction tasks with GeoGebra in STACK, e. g. letting the students solve tasks like “construct the perpendicular bisector” with GeoGebra. In case of adding constructions to the HelperTool, following the design concept, customized toolbars should be generated. Regarding the controversy mentioned above an option (to get a not-customized version) also should be added.

Two different concepts of construction-tasks with GeoGebra in STACK

- Checking the correctness of the student-submitted construction within GeoGebra (hidden), and defining a GeoGebra-object which contains the result of this check and is read by STACK with aid of the HelperTool.
- Checking the correctness of the student-submitted construction within STACK by defining maxima objects equivalent to the submitted GeoGebra-object (an example see figure 4)

⁷ An example with JSXGraph and GeoGebra is given here: Mai and Meyer, 2019

In addition an easier way of using captions and texts is in development: to add descriptions, labels and input fields into the GeoGebra-applet controlled by STACK (example see figure 7). In this context loading and saving of constructions would be useful too.

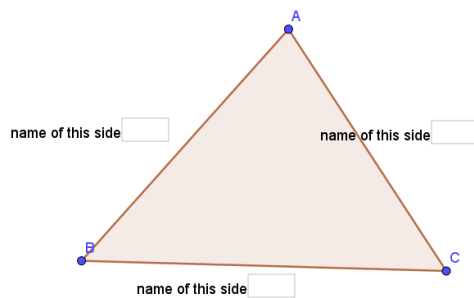


Fig. 7: Example of inputs within a GeoGebra-applet. Useable for number pyramids (Benölken, Berlinger, Hammad, & Veber, 2017) etc.

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