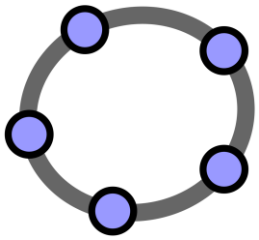

Creating and Enhancing Dynamic Worksheets with GeoGebra

GeoGebra Workshop Handout 6

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1. Introduction: The GeoGebraWiki and User Forum

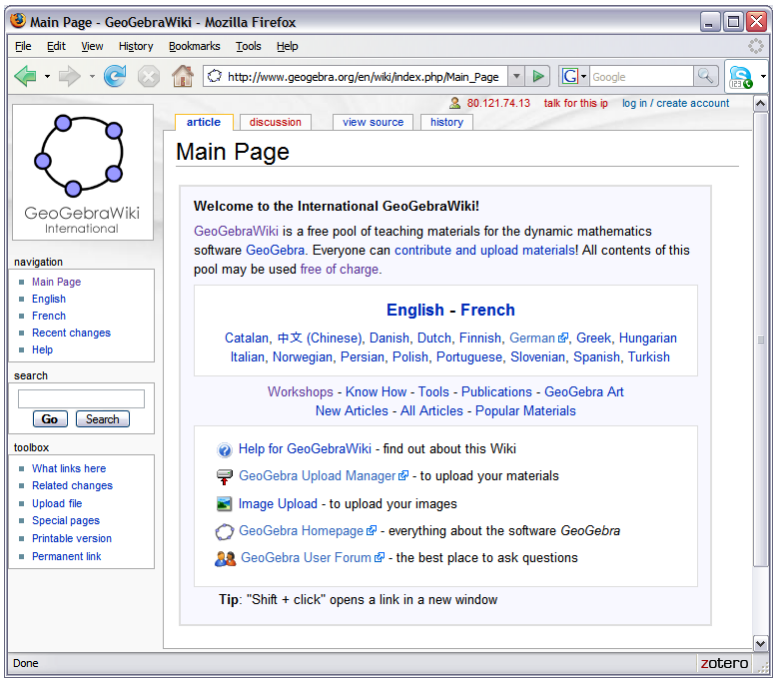
Dynamic Worksheets

GeoGebra allows you to create your own interactive instructional materials, so called *dynamic worksheets*, by exporting dynamic figures into web pages. Usually, a dynamic worksheet consists of a heading, short explanation, interactive applet, as well as tasks and directions for your students.

In order to work with dynamic worksheets your students don't need to know how to operate GeoGebra at all. The interactive web pages are independent of the software and can be provided either online or on a local storage device.

The GeoGebraWiki

The GeoGebraWiki (www.geogebra.org/wiki) is a pool of free instructional materials (e.g. dynamic worksheets) that were created by teachers from all over the world. There are different wikis for several languages (e.g. German, English, French) in order to organize their content and make them easier to access.



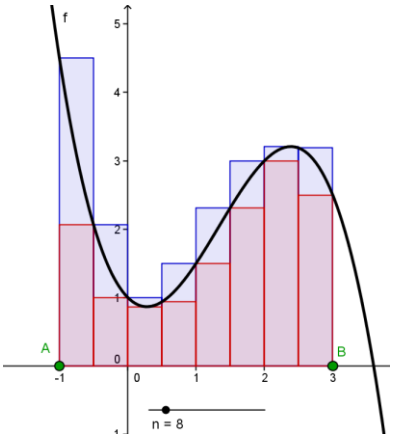
All materials on the GeoGebraWiki are under a Creative Common License (www.geogebra.org/en/cc_license/cc_license.htm). This means that you are allowed to use them for free, non-commercial use, and that you can create derivative work if you give credit to the original author.

The GeoGebra User Forum

The GeoGebra User Forum (www.geogebra.org/forum) was created to offer additional support for the community of GeoGebra users. Created for teachers and maintained by teachers, it is a platform to pose and answer questions related to GeoGebra.

The GeoGebra User Forum consists of several discussion boards in different languages allowing users to post and answer their GeoGebra related questions in their native language.

2. Lower and Upper Sum



You will now learn how to create a dynamic worksheet that illustrates how lower and upper sums can be used to approximate the area between a function and the *x*-axis, which can be used to introduce the concept of integral to students.

Preparations

- Open a new GeoGebra file.
- Show the algebra window, input field, and coordinate axes (*View* menu).

Instructions

1		Cubic polynomial `f(x) = -0.5x^3 + 2x^2 - x + 1`
2		Points *A* and *B* on the *x*-axis Hint: These points will determine the interval which restricts the area between the function and the *x*-axis.
3		Slider for the number *n* with interval 1 to 50 and increment 1
4		Enter `uppersum = UpperSum[f, x(A), x(B), n]` Hint: `x(A)` gives you the *x*-coordinate of point *A*. Number n determines the number of rectangles used in order to calculate the lower sum.
5		Enter `lowersum = LowerSum[f, x(A), x(B), n]`
6	ABC	Dynamic text `"Upper Sum = " + uppersum`
7	ABC	Dynamic text `"Lower Sum = " + lowersum`
8		Calculate the difference `diff = uppersum - lowersum`
9	ABC	Dynamic text `"Difference = " + diff`
10		Enter `integral = Integral[f, x(A), x(B)]`
11	ABC	Dynamic text `"Integral = " + integral`
12		Fix slider and text using the *Properties dialog*.

Task

Use slider *n* in order to modify the number of rectangles used to calculate the lower and upper sum.

1. Compare the values of the upper sum / lower sum to the value of the integral for different values of slider *n*. What do you notice?
2. What happens to the difference of the upper and lower sum (a) if *n* is small (b) if *n* is big?

3. Creating Dynamic Worksheets

Reducing the size of the GeoGebra window

GeoGebra will export the algebra and graphics window into the dynamic figure of the worksheet. In order to save space for explanations and tasks on the dynamic worksheet you need to make the GeoGebra window smaller prior to the export.

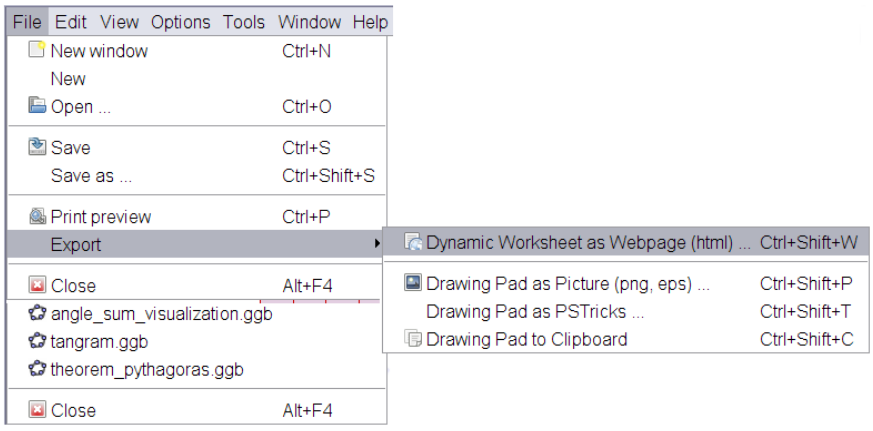
- If you don't want to include the algebra window you need to hide it prior to the export.
- Move your figure (or the relevant section) to the upper left corner of the drawing pad using the *Move drawing pad* tool (see left figure below).
  Hint: You might want to use tools *Zoom in* and *Zoom out* in order to prepare your figure for the export process.
- Reduce the size of the GeoGebra window by dragging its lower right corner with the mouse (see right figure below).
  Hint: The pointer will change its shape when hovering above an edge or corner of the GeoGebra window.

Note: Although the interactive applet should fit on one screen and even leave some space for text on the worksheet you need to make sure that it is big enough to allow students manipulations and experiments.

Exporting a dynamic worksheet

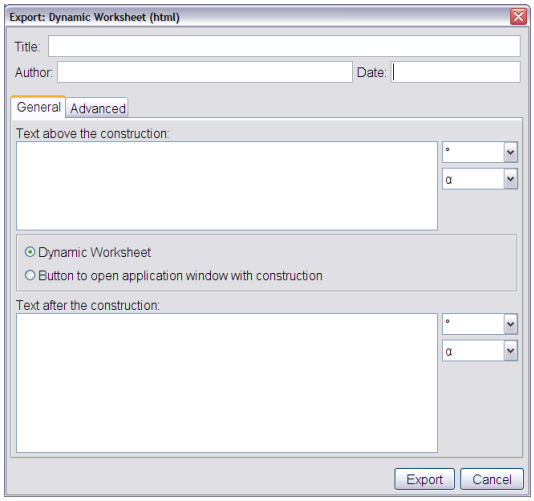
After adjusting the size of the GeoGebra window, you are now ready to export the figure as a dynamic worksheet using the *File* menu.

- *Export – Dynamic Worksheet as Webpage*
  Hint: You could also use the key combination *Ctrl – Shift – W*.



- Fill in the text fields in the appearing window (title of the worksheet, name of the author, and date).

- Type a short explanation of the dynamic figure into the text field *Text above the construction*.
- Enter tasks and directions for students into the text field *Text after the construction*.
- Click *Export* and save your dynamic worksheet.
  Hint: GeoGebra will create several files which always need to stay together in order to maintain the functionality of the dynamic worksheet. We recommend creating a new folder (e.g. worksheets) prior to saving your dynamic worksheet.



Some useful information

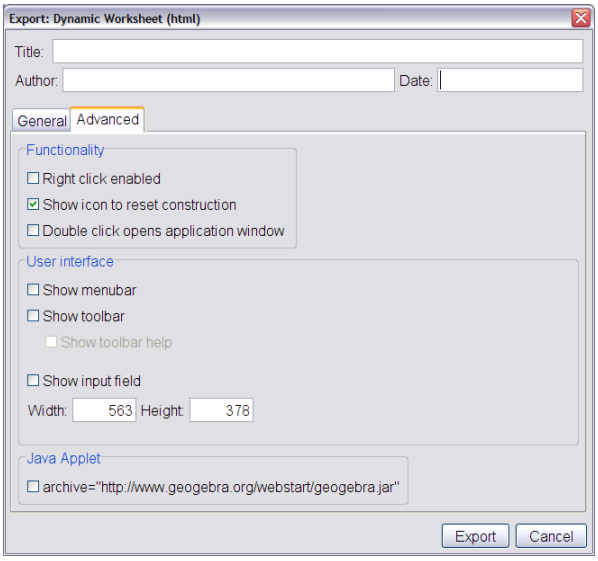
After saving the dynamic worksheet it will be automatically opened in your web browser. Check the text you inserted as well as the functionality of the interactive applet. If you want to change your dynamic worksheet go back to the GeoGebra file and make your changes to the figure. Export the figure again (you can use the same file name to overwrite the old worksheet) in order to apply your changes.
Hint: You can change the text of the dynamic worksheet in the same way.

GeoGebra automatically saves your entries in the export window for dynamic worksheets. If you want to make changes to your figure while filling in the export dialog you can just close it and continue later on.

You can save several dynamic worksheets into the same folder. Thereby, the files with the extension .jar are just created once in this folder. If you want to provide one of the dynamic worksheets to your students you need to copy the jar-files in addition to the corresponding ggb- and html-files.

4. Enhancing Dynamic Worksheets

The export dialog window for dynamic worksheets consists of two tabs: *General* and *Advanced*. In the last activity you used tab *General* in order to add explanations, tasks, and directions to the dynamic figure prior to the export. You will now learn how to enhance your dynamic worksheet by including different features in the interactive figure using the tab *Advanced*.



Functionality

- Right click enabled: Your students will be able to right click objects or the drawing pad in order to access the features of the context menu (e.g. show / hide object or label, trace on / off, *Properties dialog*).
- Show icon to reset construction: A reset icon is displayed in the upper right corner of the interactive applet allowing your students to reset the interactive figure to its initial state.
- Double click opens application window: Your students will be able to open a full GeoGebra window by double clicking the interactive applet.

User interface

- Show menubar: The menubar is displayed within the interactive applet.
- Show toolbar: The toolbar is displayed within the interactive applet and allows your students to use the geometry tools.
- Show toolbar help: In combination with the toolbar, you can also display the toolbar help within the interactive applet. If you want your students to

use geometry tools they can use the toolbar help in order to find out how to operate the different tools on their own.

- Show input field: The input field is displayed at the bottom of the interactive applet allowing your students to use algebraic input and commands for their explorations.
- Width and height of the interactive applet: You can modify the width and height of the interactive applet.
  Note: If you reduce the size of the applet important parts of the dynamic worksheets might be invisible for your students.
  Hint: If you include the menubar, toolbar, or input field the height of the interactive applet is increased automatically.

Task

Use the dynamic figure you created earlier and export it as an enhanced dynamic worksheet. Use the *Advanced* tab to try out different options and check how the applet of your dynamic worksheet is changed accordingly.

5. Providing Dynamic Worksheets to Students

You can provide your dynamic worksheets in several ways to your students. However, in all cases it is very important to keep all the files together which were created during the export process.

Note: The files created have different file name extensions (*.ggb*, *.html*, *.jar*). If one of these files is missing your dynamic worksheet won't function any more.

Local storage device

Copy all files into the same folder before saving this folder on a local storage device (e.g. flash drive, CD). Have your students copy the whole folder on their computers. Your students need to open the file with the name extension *.html* in their Internet browser.

Via Internet

If you want to provide your dynamic worksheet online you need to upload ALL files to the same location on a web server. After uploading your files to a web server you can provide a hyperlink on your personal website or tell your students how to directly access the worksheet using the address field of an Internet browser.

The GeoGebra Upload Manager

If you don't have your own web space, we have made it easy for you to upload your dynamic worksheets to a web server. It is called the *GeoGebra Upload Manager* (www.geogebra.org/en/upload). After creating a user account you can upload your files to your assigned folder. Since the GeoGebra Upload Manager was specially created for dynamic worksheets you ONLY need to upload the files with the extension *.html* and *.ggb* (and NOT the *.jar* files).

Create your own account

1. Access the ***GeoGebra Upload Manager*** www.geogebra.org/en/upload
2. Click on ***Login*** (upper right corner of the browser window)
3. Click on ***Register*** and enter a username, password, and your email address.
   Note: You will get an email confirming your registration. It contains an activation code for your account.
4. ***Check your email*** and copy the activation code. Click the link provided in the email in order to access the account activation web page.
5. On the ***account activation web page*** enter your username and paste the activation code into the corresponding text field. Click *Activate account*.

Create your personal upload folder

1. ***Login*** to the GeoGebra Upload Manager.
2. Look for the ***folder called "english"*** and open it.
3. ***Create your personal upload folder*** within the "english" folder (e.g. Lastname_Firstname).
   Hint: Scroll down to the end of this page and fill in the text field below the heading *Create new directory*. Click *Make dir.*
4. Note: You can create new folders within your personal upload folder in order to organize your uploaded files.

Upload your files and provide them to your students

1. Look for your newly created ***personal upload folder*** and open it.
2. Scroll down to the end of this page until you can see the ***heading Upload File***.
3. Click the ***Browse button***. Navigate through the folders on your computer until you find the file you want to upload. Select the file and click *Open*.
4. Enter a ***file description*** into the corresponding text field.
5. Click **Upload File**.
6. Note: If you want to provide a dynamic worksheet to your students, you need to upload the corresponding .ggb file as well as the .html file to your personal upload folder. You don't need to upload the .jar files!
7. Look for the file you just uploaded into your personal upload folder. Right click the file name (MacOS: *Ctrl*-click) and select ***Copy Link Location***

from the appearing menu.
Note: The web address of your file is copied to your clipboard.

8. ***Provide the link to your students***: Paste the web address of your file into a text processing document or use it in order to create a link to your file on your personal web page. Your students will need the link address in order to access your files.

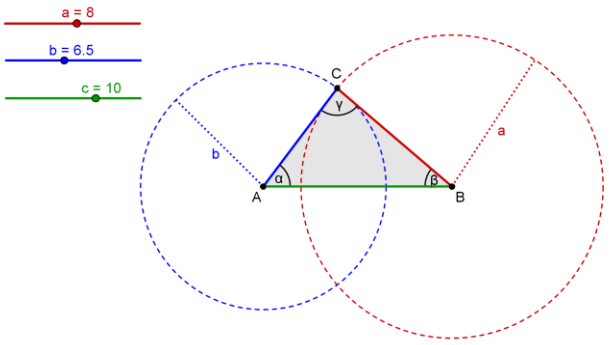
6. Visualizing Triangle Inequalities

You will now create a dynamic worksheet that illustrates the construction steps for a triangle whose three side lengths *a*, *b*, and *c* are given. Additionally, this worksheet will allow your students to discover triangle inequalities.

Note: The triangle inequalities $a+b>c$, $b+c>a$, and $a+c>b$ state that the sum of two side lengths of a triangle is greater than the length of the third side of the triangle. If the triangle inequalities are not fulfilled for a certain set of side lengths, it is not possible to construct a triangle using the given lengths.

Preparations

- Open a new GeoGebra file
- Hide the algebra window, coordinate axes, and input field (*View* menu).



Introduction of new tools

	**Segment with given length** **New!** Hint: First click determines the starting point of the segment. Enter the length of the segment into the appearing text field.
	**Circle with center and radius** **New!** Hint: First click determines the center of the circle. Enter the length of the radius into the appearing text field.

Hints: Don't forget to read the toolbar help if you don't know how to use a tool. Try out new tools before you start the construction.

Instructions

1		Sliders a, b, and c for the side lengths of the triangle
2		Set the sliders to *a* = *8*, *b* = *6.5*, and *c* = *10*
3		Segment *d* with given length *c* Hint: Points *A* and *B* are the endpoints of the segment.
4		Circle *e* with center *A* and radius *b*
5		Circle *f* with center *B* and radius *a*
6		Intersection point *C* of the two circles *e* and *f*
7		Triangle *ABC*
8		Interior angles *α*, *β*, and *γ* of triangle *ABC*

Enhancements

Prepare your triangle construction for the export as a dynamic worksheet.

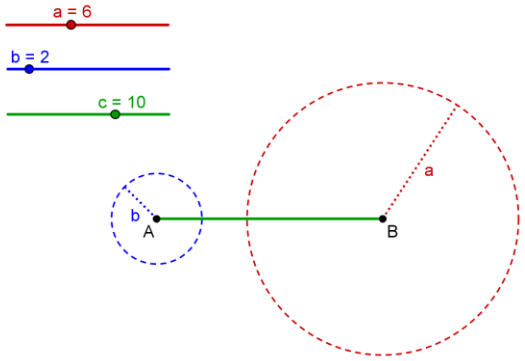
9		Point *D* on circle *e*
10		Segment *g* between points *A* and *D*
11		Midpoint *E* of segment *g*
12		Enter *text1*: "b" and attach it to point *E*
13		Point *F* on circle *f*
14		Segment *h* between points *B* and *F*
15		Midpoint *G* of segment *h*
16		Enter *text2*: "a" and attach it to point *G*
17		Match colors of corresponding objects.
18		Show the Navigation bar (*View* menu).
19		Open the *Construction protocol* and show column *Breakpoint* (*View* menu of the *Construction protocol dialog*)

20	Change the order of construction steps so that the radii of the circles and the attached text show up at the same time. Hint: You might also set some other breakpoints (e.g. show all sliders at the same time).
21	In the *View* menu of the *Construction protocol dialog* check *Show breakpoints only*.

Tasks

(a) Export your triangle construction as a dynamic worksheet.

(b) Come up with explanations and tasks for your students that guide them through the construction process of the triangle and help them explore the triangle inequalities by modifying the given side lengths using the sliders.



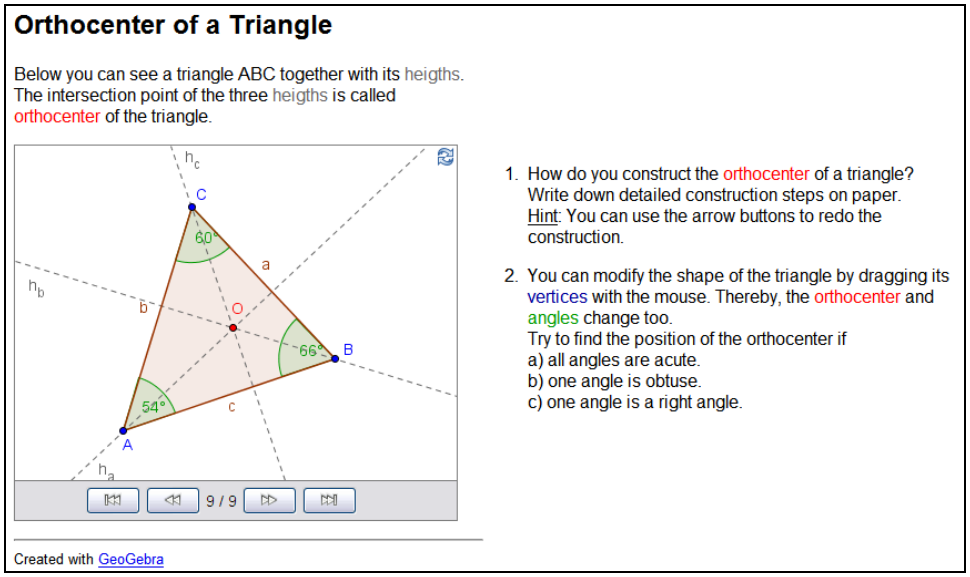
7. Design Guidelines for Dynamic Worksheets

The following design guidelines for dynamic worksheets are the result of a formative evaluation of dynamic worksheets created by teachers in our NSF MSP classes during fall 2006 and spring 2007. The guidelines are based on design principles for multimedia learning stated by Clark and Mayer[1].

These guidelines were summarized to address and avoid common mistakes during the creation process of dynamic worksheets as well as to increase their quality with the hope that they will foster more effective learning. Although some of these guidelines may seem obvious, we have found it very important in our work with teachers to discuss and explain them in detail.

The following figure shows an entire dynamic worksheet created with GeoGebra that allows students to explore properties of the orthocenter of a triangle. By modifying the dynamic construction students can examine the orthocenter of a great variety of triangles instead of just one special case. Several key words within the explanation and tasks match the color of the corresponding objects in order to facilitate finding them within the construction. Furthermore, the tasks are placed next to the dynamic construction in order to fit all information on one screen and avoid additional cognitive load through scrolling.

[1] Clark, R. and Mayer, R.E. (2002): e-Learning and the Science of Instruction. San Francisco: Pfeiffer, 2002



Design Guidelines 1: Layout of Dynamic Worksheets

Avoid scrolling

Your entire worksheet should fit on one screen. Students should not have to scroll between the tasks and the interactive figure. We consider 1024x768 or 1280x1024 pixels as today's usual screen size which constrains the size of the dynamic worksheet. Using an HTML editor like NVU you can use tables to arrange text, images, and interactive figures so they fit on one screen. If this is not possible, consider breaking the dynamic worksheet into several pages.

Short explanation

At the beginning of a dynamic worksheet, you should give an explanation of its content. Keep the text short (no more than one or two sentences) and write it in a personal style.

Few tasks

You will usually add questions or tasks to make sure that your students use the worksheet actively. Place these tasks close to the interactive applet (e.g. directly below it). Don't use more than three or four questions / tasks to avoid scrolling. If you have more tasks, consider breaking your worksheet into several pages.

Avoid distractions

Make sure that your dynamic worksheet just contains objects that are relevant for the objectives. Neither use unnecessary background or purely decorative images, nor background music on the web page in order not to distract your students from reaching the objectives.

Design Guidelines 2: Dynamic Figures

Interactivity

Allow as much interactivity as possible in your dynamic figure. As a rule of thumb, all visible objects should be movable or changeable in some way. Your dynamic figure should provide plenty of freedom to explore the relations of its mathematical objects and discover mathematical concepts.

Easy-to-use

Try to make your dynamic figure as easy to use as possible. If an object can be moved or changed, try to make this obvious, e.g. all movable points could be red or larger in size. If you don't want objects to be changed, fix them (e.g. text, functions or slider positions) so they cannot be moved accidentally.

Size matters

Your dynamic figure should be large enough to allow all intended manipulations, but small enough to fit on one screen and still leave sufficient space for explanations and questions on the surrounding web page.

Use dynamic text

Dynamic text, like the length of a changeable segment, should be placed close to the corresponding object in your applet).

Avoid static text

Too much text can easily clutter your interactive applet. Instead, place static text like explanations or questions on the web page that includes your dynamic figure.

First appearance

When a dynamic worksheet is opened you should be able to read all labels and important information. For example, a point label should not be crossed by a line.

Design Guidelines 3: Explanations and Tasks

Short, clear and personal style

Try to write your explanations and questions in a short, clear and conversational style. Use the term ‘you' within the text and try to address the students directly.

Small number of questions

Limit your number of questions or tasks per worksheet to three or four to avoid scrolling. If you want to ask more questions, create a new worksheet.

Use specific questions

Avoid general questions like ‘What is always true about X?' and make clear what the students should do, e.g. `What happens to X when you move Y?'. We recommend that your students should take notes while they work with a dynamic worksheet. If you want them to write down their answers on paper, say so on the worksheet.

Refer to your applet

Your text should support the use of your interactive applet. For example, try to explain a new term by referring to your applet instead of using an isolated textual definition. Additionally, you can color certain keywords to match the formatting style of the object they refer to. This makes the text easier to read and helps your students to find corresponding representations of the same object.

Your audience are learners

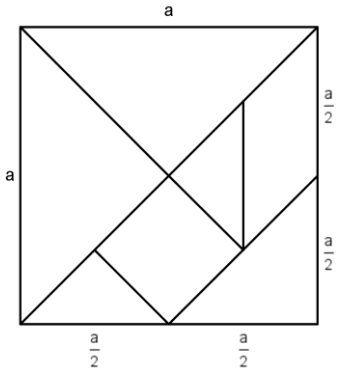
If you want to provide information for other educators (e.g. lesson plan, solutions) do so in a separate document (e.g. web page, pdf-document). Your students should not be distracted or confused by such information.

Demonstration figure

If your interactive figure is meant for presentation only it might be better to have no tasks or questions on the web page. If you include text, it should be understandable for students as well.

8. Creating a ‘Tangram’ Puzzle

In this activity you will create the ‘Tangram’ puzzle shown at the right hand side. It consists of 7 geometric shapes which can all be constructed using the side length *a* of the main square. Check out the dynamic worksheet *11_tangram_puzzle.html* in order to find out how a ‘Tangram’ works.



Task 1: Figure out the side lengths of each part

In order to construct the parts of the 'Tangram' puzzle you need to figure out the individual side lengths of the seven geometric figures first. They all depend on the side length *a* of the main square.

Hint: In some cases you might want to look at the diagonals or height. Their lengths can be expressed more easily using the variable *a* than the lengths of the corresponding sides.

Task 2: Construct the individual parts of the 'Tangram'

1. Enter the number `a = 6`. It will provide a basis for the construction of all triangles and quadrilaterals necessary for your 'Tangram' puzzle.
2. Begin each of the geometric figures using a segment with given length. This will allow you to drag and rotate the figure later on.
   Hint: You need to figure out the side lengths of the geometric shapes before you are able to construct them in GeoGebra.
3. Construction hints:
   a. If the height of a right triangle is half the length of the hypotenuse you might want to use the theorem of Thales for the construction (see practice block 1).
   b. If you know the legs of a right triangle you might want to construct it similar to the square construction presented earlier.
   c. For constructing a square using its diagonals, it is helpful to know that they are perpendicular and bisect each other.
   d. For constructing the parallelogram it is helpful to know the size of the acute angle.
4. Check your construction by trying out if you can manage to create a square with side length *a* using all figures.
5. Arrange the geometric shapes arbitrarily around the edges of the interactive applet. Export the figure to a dynamic worksheet and add an explanation for your students.

9. Challenge of the Day: Enhance Your 'Tangram' Puzzle

With these geometric shapes other figures than a square can be created as well. Search the Internet for a 'Tangram' figure other than a square (e.g. *12_tangram_cat.png*) and import this figure into the drawing pad. Export the GeoGebra construction again using a different name and different instructions (see *13_tangram_puzzle_cat.html*).