

## Web-based graphic tool for science and engineering education

### Introduction

Functions expressing relationships between physical quantities are at the heart of science and engineering. Sketching graphs of functions is a core skill every scientist and engineer needs, yet many incoming first-year students find it difficult. A web-based method combining visual and kinesthetic techniques has been developed to facilitate the development of this important skill.

Instead of multiple choice, calculated formula/numeric, true or false and like questions this graphic tool uses hand-drawn sketches on a computer screen as input. Upon submitting their answers, pre-set solutions to the questions are plotted on the canvas, relative errors are calculated with the area between the solution and the sketch highlighted to provide visual feedback to students.

The project was motivated by discussions with students taking Maths for Chemistry class at Leeds University (2012–2013).

### Methods

- HTML canvas element,
  - JavaScript and
  - PHP
- were used for the development of

- 1) a user-friendly interface to create assignments on-line,

Name of assignment:

Assignment1

Title

Example - Batch reactor:  $A \rightarrow B$

Text

Example - Batch reactor:  $A \rightarrow B$

Function

$f(x) = 4 - 4 \exp(-x)$

x label: time / min

right: centre Xmin: 0 Xmax: 5

x ticks: 1,2,3,4,5

y label: [B] / M

top: middle Ymin: 0 Ymax: 4

y ticks: 1,2,3,4

✓ Axes intersect at bottom left corner

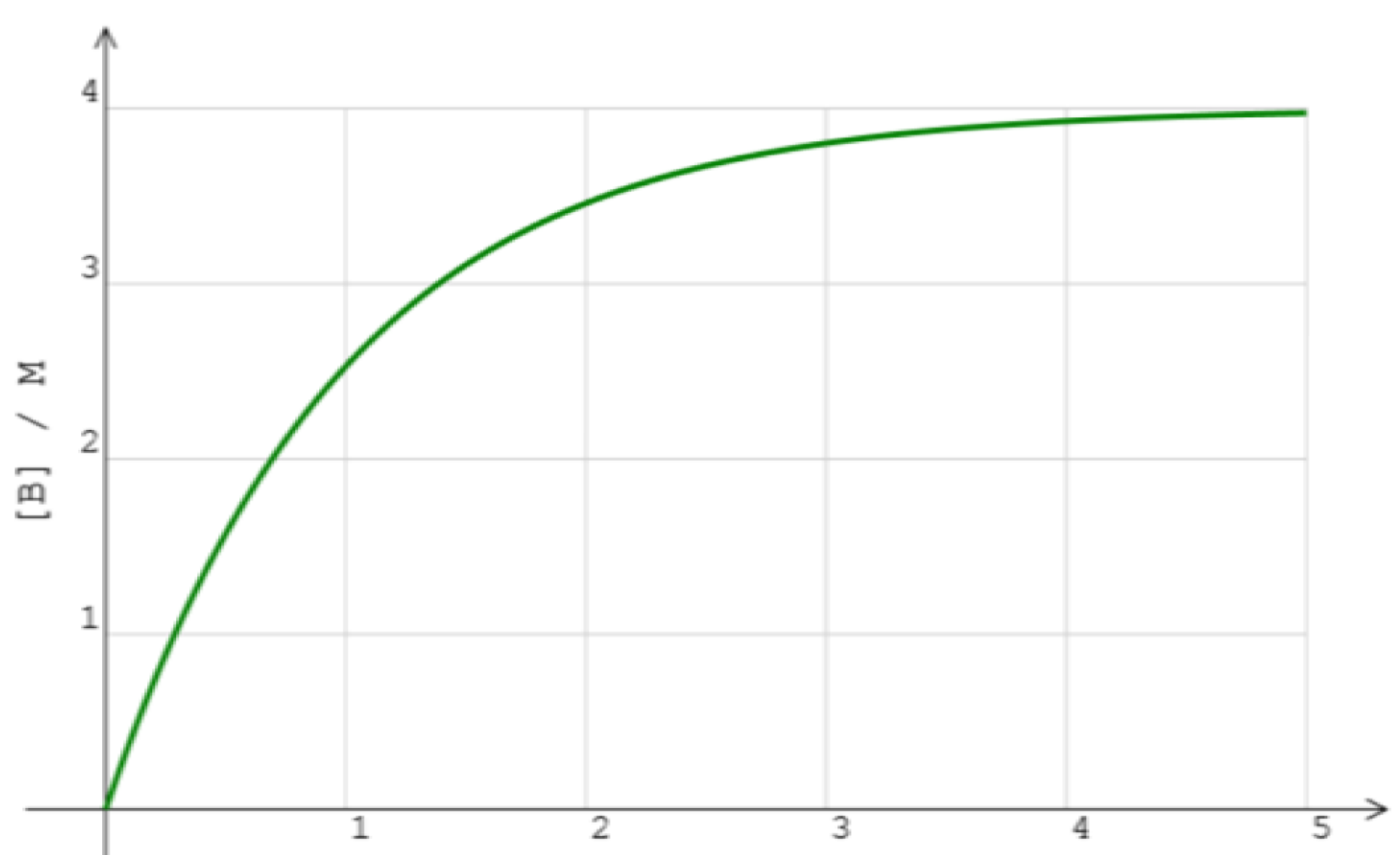
Preview Save

Example - Batch reactor:  $A \rightarrow B$

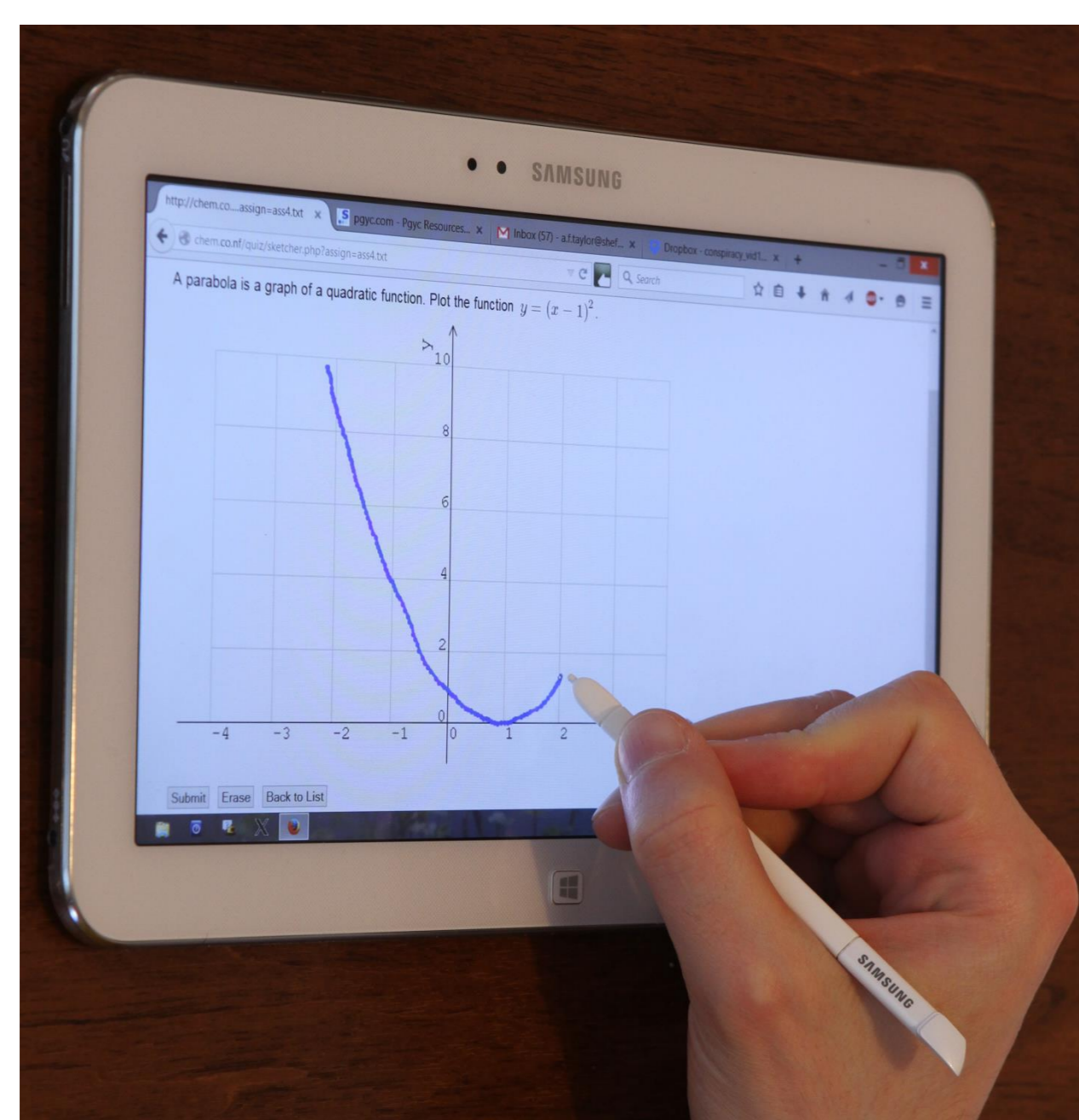
The problem is described in a few sentences above the canvas. MathJax is supported to make equation edition easy. In this example the function to be sketched is

$$[B] = [A]_0 - [A]_0 e^{-kt}$$

where  $[A]_0 = 4 \text{ M}$  and  $k = 1 \frac{1}{\text{min}}$ . By clicking "Preview" at any step of the process the teacher can make sure that everything is correct before saving the assignment.



- 2) a web interface for students to sketch answers,

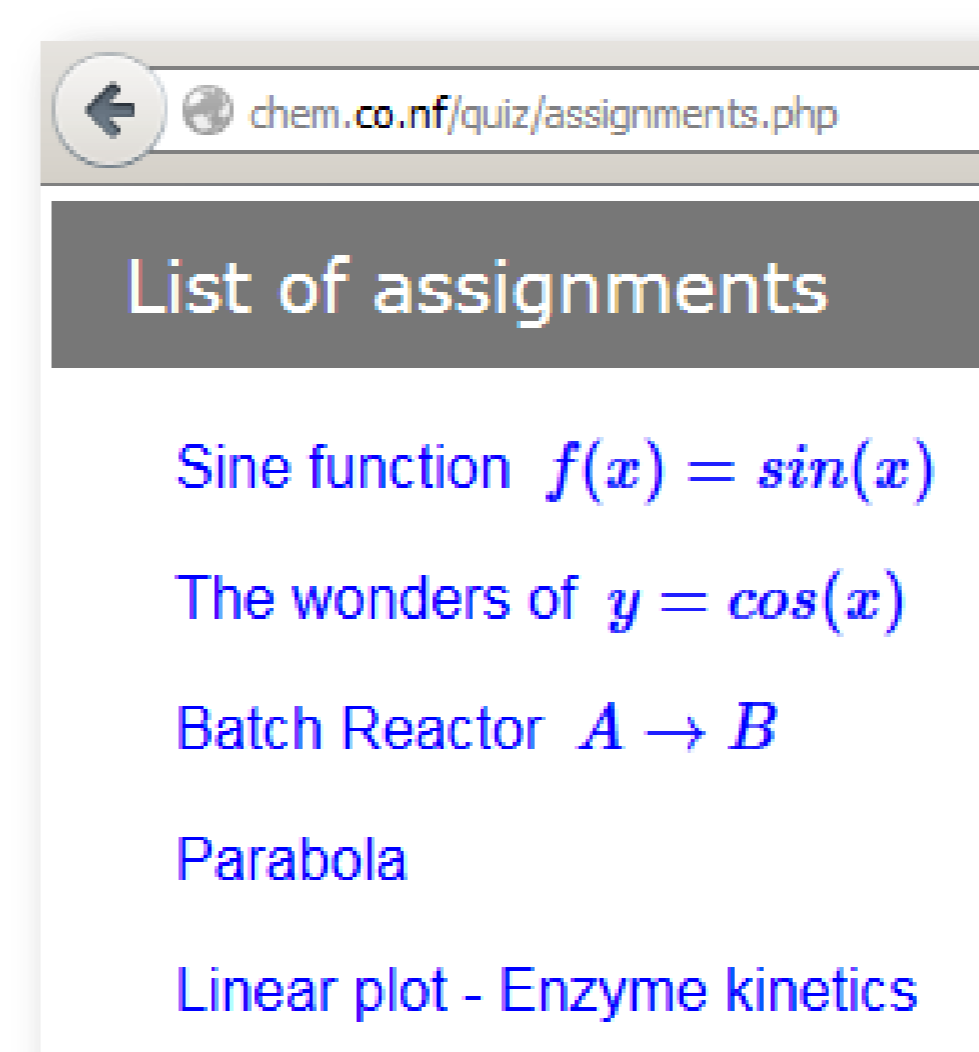


*Free-hand mouse or stylus input (supported by new editions of major internet browsers).*

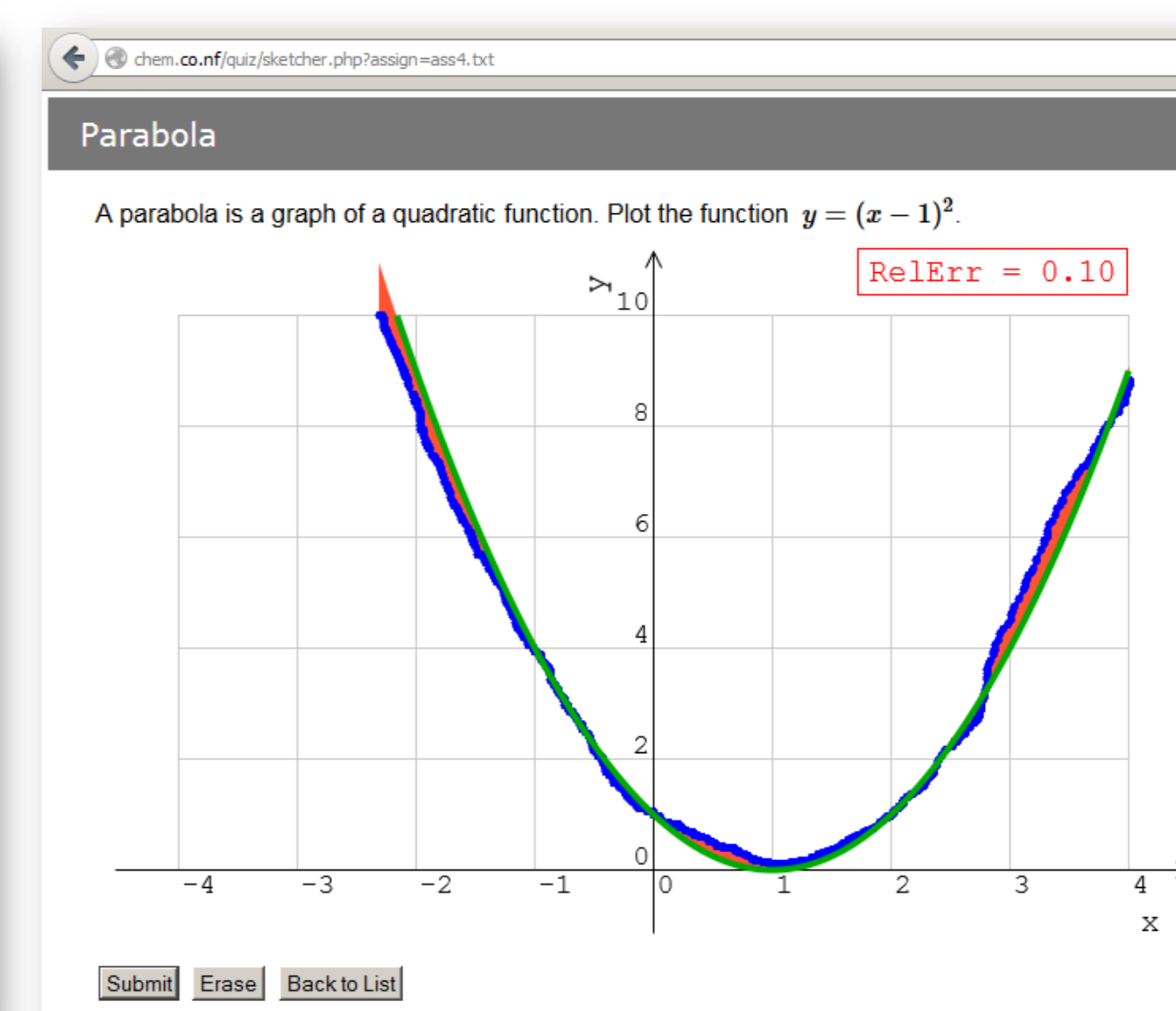
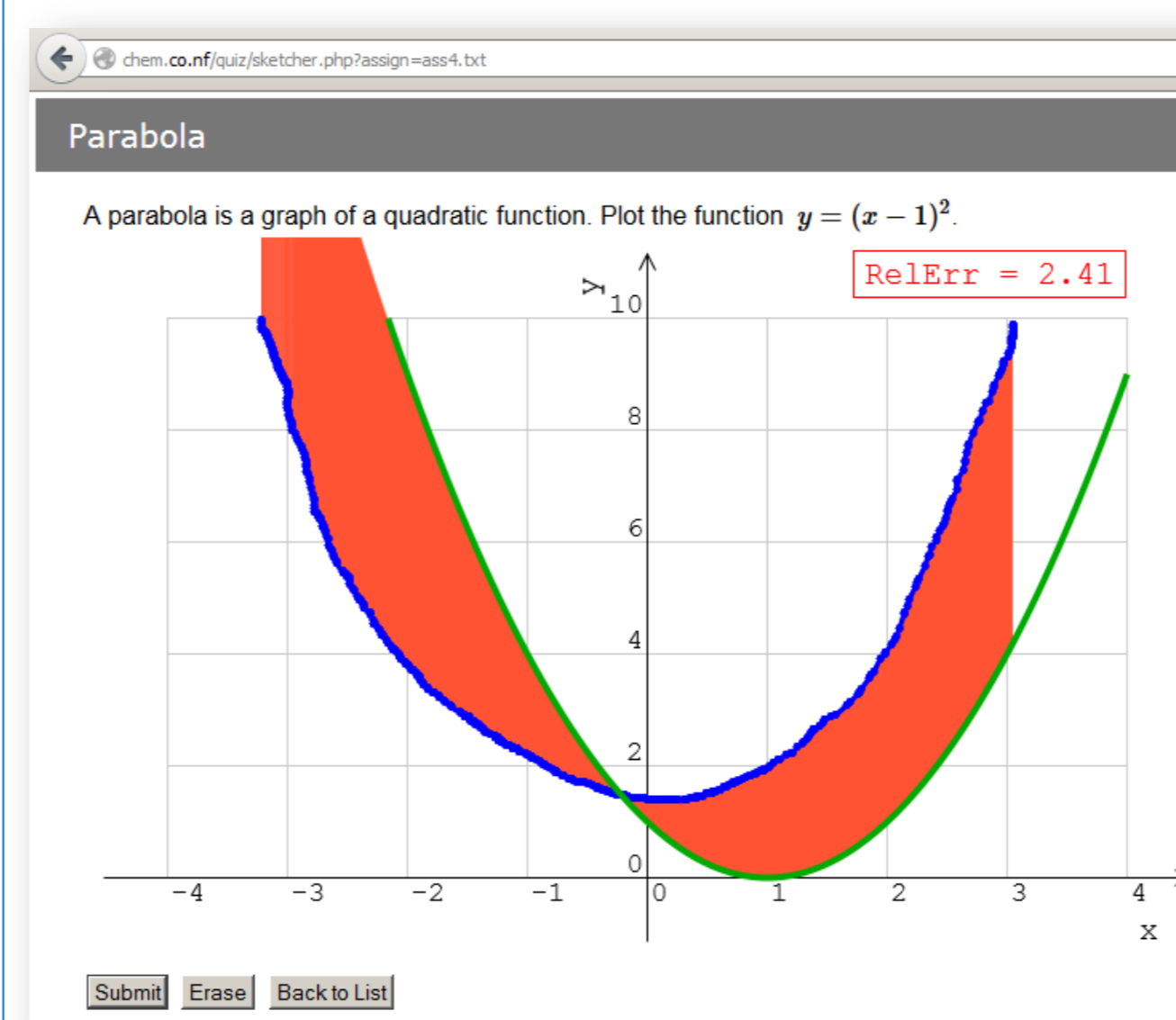
*Erase sketches if needed before submitting.*

*Parameters in exercises can be randomized.*

- 3) related file management on server. (Writing assignment scripts with text editor is also possible.)



Once exercises are written and saved, students can start practicing by clicking an item on the list. After the question loads students sketch their answer, a parabola – in this exercise.



Students are allowed to erase **sketches** before submission

When a graph sketch is submitted, the **pre-set function** loads

**Error** (area between solution and sketch) is **highlighted**;  
**relative error is also displayed**

Visual feedback to kinesthetic exercise

### Future work

Develop question bank and start testing

Add features: collect and compile data allowing teachers to monitor progress and identify common mistakes  
save canvas enabling students to monitor own progress

Improve random parameter handling and interface

Image display

Develop similar tool for teaching/learning organic chemical reactions

### References

1. [http://www.w3schools.com/tags/ref\\_canvas.asp](http://www.w3schools.com/tags/ref_canvas.asp)
2. <http://en.wikibooks.org/wiki/JavaScript>
3. [http://en.wikibooks.org/wiki/PHP\\_Programming](http://en.wikibooks.org/wiki/PHP_Programming)