

## Scalable Vector Graphics as Online Visualization of Learning Progress for Computer Based Online Trainings

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**Abstract:** *The paper is about an approach to use the well known open standard of Scalable Vector Graphics (SVG) to visualize the learning progress of participants of Computer Based Online Trainings (CBOT). After the students completed an online test, they can call their visualized "trend charts" showing the learning progress of a participant. A specific perl module has been developed for dynamic creation of the path of cubic bezier splines with a great number of points to be shown within the SVG-picture. The work with the model will enable students to compare their activities on several knowledge topics and to divide them into "learning types".*

**Key words:** *Scalable Vector Graphics, Cubic Bezier Splines, Trend Chart, Computer Systems and Technologies, Online Visualization, Computer Based Online Training.*

### INTRODUCTION

During the preparation of trainees to pass the certification exams as "Webdeveloper" provided by the European Association of Webmasters [5] a lightweight model of computer based online training for exam preparation [2] is developed. The trainees are offered various online tests in several knowledge topics. To inform both the trainees and the trainer about the learning progress – or to be precise: about the up- and downward trends of the preparation tests – a visualization is implemented. As a main topic, the implementation uses only open standards and it is accessible online immediately after the trainees' online test was completed. Therefore the visualization uses scalable vector graphics – an open standard provided by the W3C. Although Microsoft's Internet Explorer does not yet come with native support of SVG, the SVG-Interest Group is developing a SVG-plugin to work with IE [3]. Other Browsers support SVG natively.

### OBJECTIVES

A web based user interface has been developed to give both the trainees and the trainer the ability to see their improvements of knowledge and to compare the activities among the trainees in exams preparation. Learning types are detected using cubic Bezier spline.

An algorithm for creating cubic Bezier splines to produce scalable vector graphics has been written using Perl [4], one of the most used server-side languages. This algorithm was included in a newly created perl module called SVG::Spline.

### THE "CUBIC BEZIER SPLINES"

As known, splines are used for interpolation between data points for smoothing the functions path to give a better understanding of its behaviour [1].

The theory of cubic splines comes with polynomials of third degree between every two data points. At the end there is a curve consisting of pieces of polynomials through the given data points. The first and second derivatives of these polynomials are continuous, so it looks like one curve through all the data points from the beginning till the end.

Unfortunately, SVG has no possibility to define "splines". But it offers so called "Bezier"-curves [1]. Bezier-curves are defined by control points that form the underlying curve.

From the trainees' test results we have data points  $S_0, \dots, S_n$ . Our spline should go through all of them. We need to calculate the "control points" for the Bezier-curves in such a way, that these control points form the splines we need.

A short overview of Bezier-curves and splines is given in [1]. There you can find, that the control points and the data points are connected in the following way:

$$B_0 = S_0, B_n = S_n . \text{ For } B_1, B_2, \dots, B_{n-1} \text{ and } S_1, S_2, \dots, S_{n-1}$$

we have to solve the linear equations written in matrix form:

$$\begin{pmatrix} 4 & 1 & 0 & 0 & \dots & 0 & 0 & 0 \\ 1 & 4 & 1 & 0 & \dots & 0 & 0 & 0 \\ 0 & 1 & 4 & 1 & \dots & 0 & 0 & 0 \\ 0 & 0 & 1 & 4 & \dots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & \dots & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \dots & 4 & 1 & 0 \\ 0 & 0 & 0 & 0 & \dots & 1 & 4 & 1 \\ 0 & 0 & 0 & 0 & \dots & 0 & 1 & 4 \end{pmatrix} \begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ \vdots \\ B_{n-4} \\ B_{n-3} \\ B_{n-2} \\ B_{n-1} \end{pmatrix} = 6 \begin{pmatrix} S_1 - \frac{S_0}{6} \\ S_2 \\ S_3 \\ S_4 \\ \vdots \\ S_{n-4} \\ S_{n-3} \\ S_{n-2} \\ S_{n-1} - \frac{S_n}{6} \end{pmatrix}$$

$$M \times B = S$$

or shorter:  $M$  . To solve it, we have to find the inverse matrix of the "one-four-one"-matrix :

$$B = M^{-1} \times S$$

The inverse matrix  $M^{-1}$  can be defined in a recursive manner. More over, it is symmetric. So we need to compute only one fourth of the (n-1) x (n-1) coefficients.

It is behind the scope of that paper, how the Perl Module *SVG::Spline* does all the maths. Nevertheless – it has been proven, that solving the equations is done in a very short time of less than one second, even for 100 or more data points. So it seems to the trainees, that they can access their visual results immediately after completing an exams preparation test.

### TYPES OF LEARNING CURVES

As a main result, we can observe three types of learning curves in conjunction with memorization.

1. Participants, who are already familiar with the knowledge topic.
2. Participants, who improve their knowledge continuously from the beginning till the last exam preparation test.
3. Participants, who temporarily forgot some answers but after one more preparation tests came back to their level of knowledge.

On the other hand, we can observe two types of learning curves in conjunction with the number of tests completed.

1. Rarely testing trainees.
2. Frequently testing trainees.

The following examples demonstrate the above mentioned types. The trainees had to complete the tests during the period, when this topic was covered for about one week. They repeated again the tests with randomly chosen questions after a second week, where other knowledge topics were covered.

## Results for: "P176187" (Topic: GWP)

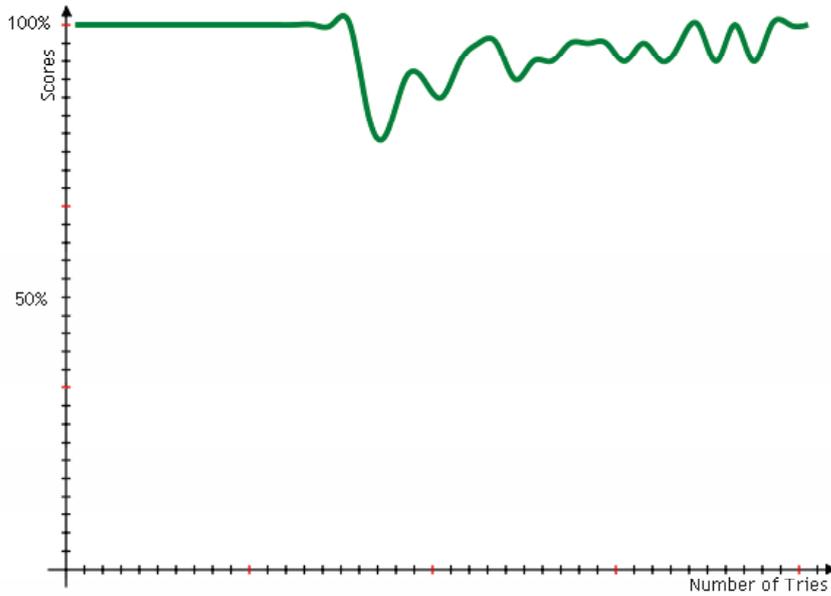


Fig.1. An example of a learning curve of some frequently testing participant, which was already familiar with the knowledge topic

## Results for: "P187179" (Topic: GWP)

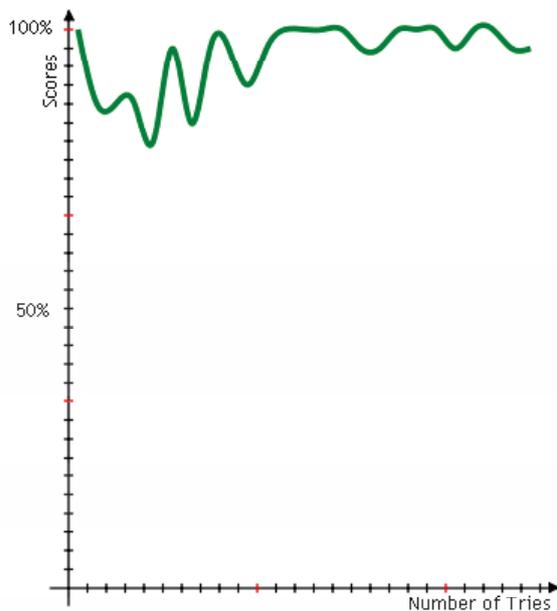
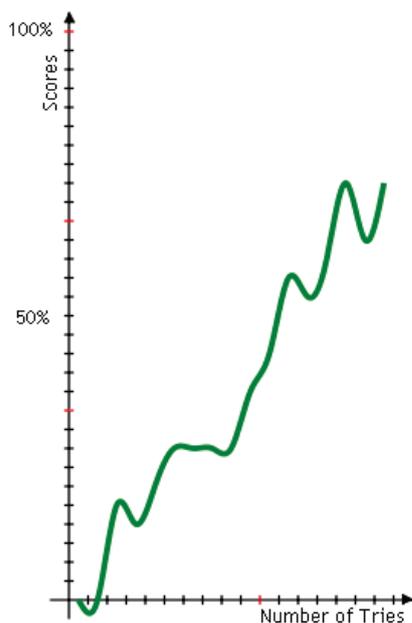


Fig.2. Another example of a learning curve of some participant, which was already familiar with the knowledge topic

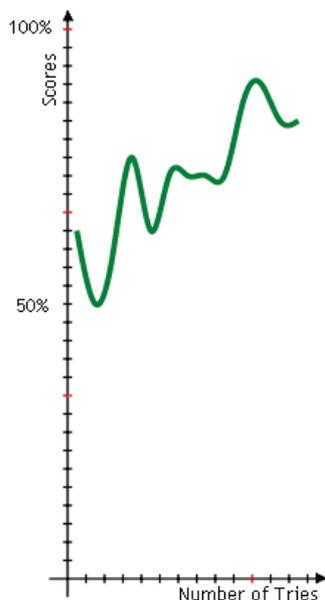
## Results for: "P149144" (Topic: JS)



SVG generated by Horst Liske, 2010-06-25 at 09:01:48 in 12.482 ms.

Fig.3. An example of a learning curve of some participant, which improved his knowledge continuously from the beginning till the last exam preparation test

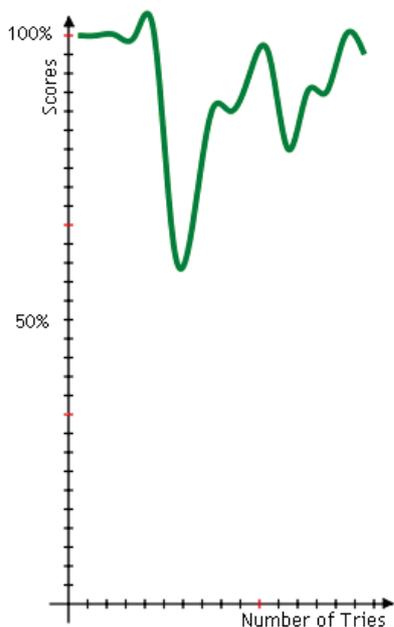
## Results for: "P172187" (Topic: XML)



SVG generated by Horst Liske, 2010-06-25 at 09:02:23 in 10.267 ms.

Fig.4. Another example of an upward trend of a learning curve

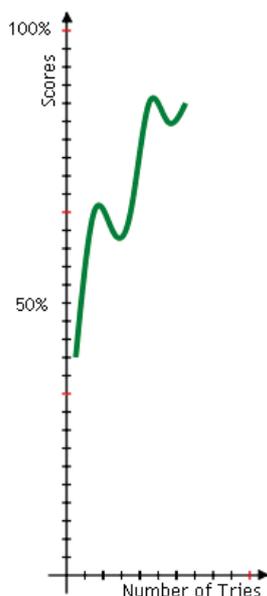
## Results for: "P145159" (Topic: GWP)



SVG generated by Horst Liske, 2010-06-25 at 09:01:03 in 15.625 ms.

Fig.5. An example of a learning curve of some participant, which temporarily forgot some answers but after one more preparation tests came back to his level

## Results for: "P179172" (Topic: HTML)



SVG generated by Horst Liske, 2010-06-25 at 09:03:36 in 9.843 ms.

Fig.6. An example of a learning curve of some rarely testing trainee

## Results for: "P172187" (Topic: JS)

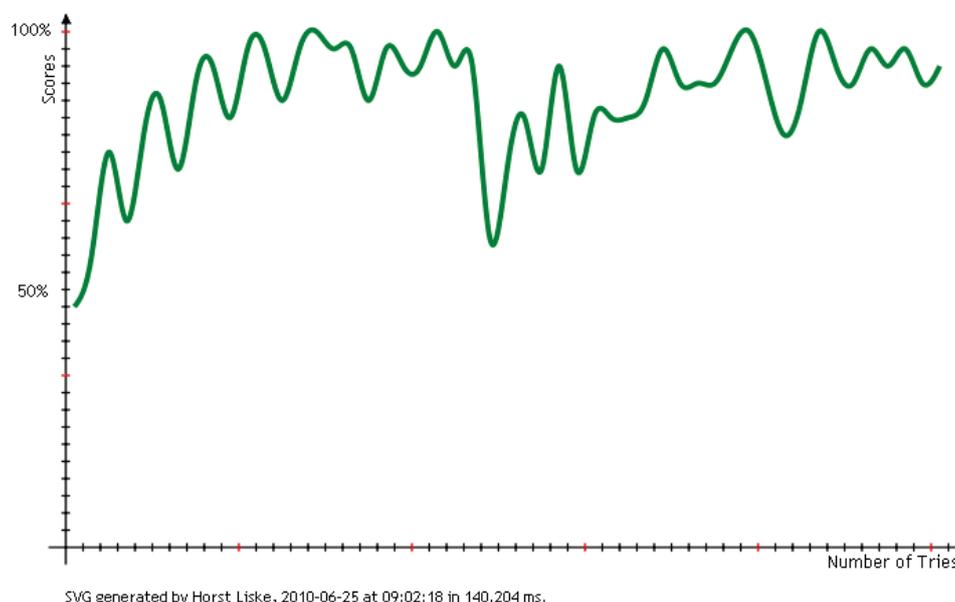


Fig.7. An example of a learning curve of some frequently testing trainee

### CONCLUSIONS AND FUTURE WORK

The Visualization as Cubic Bezier Spline gives a good imagination about the learning progress. An automated classification into the types of participants is presently being investigated. A user interface exists, where an user can insert bar charts, polynomes and scoring marks into the spline graphics. Some regression function will be introduced in future time to show the average learning path of the participants.

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