Wims Is a Magic Server

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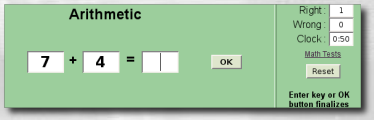
I recently encountered a group of enthusiastic teachers, who wanted to convince me to try a new e-learning environment, featuring easy quizzes:



However I was sceptical: computer quizzes have been used since the seventies, and computers have much evolved since then. Using such sophisticated tools to make such a basic environment looks like a lack of imagination.
You know... according to Moore's law, today's computers should run 2^{15} times faster than those who were used to make men land on the moon. Writing new quiz programs seems futile.

Nevertheless, I found quizzes to be interesting when they are randomly generated from huge question and answer databases. Wims can do that, and other e-learning systems can do it too. But Wims can do more: it comes with state-of-the-art syntax analyzers, which understand a variety of specialized languages, which enables the server to deal with open answers to open questions.

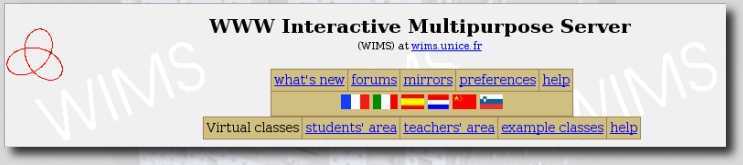
Have you ever tried to author an interactive exercise for your students? If so you may have found that you worked for two hours to create an interaction lasting ten minutes for the average student. So the throughput is about 15:1 .

This throughput ratio can be bigger or smaller, depending on your ambition and the complexity of the interactive sequence. If your ambition is to produce it as a TV show, a throughput of 30,000:1 would not be surprising.

Now, what if your next class is tomorrow? How can you author an interesting sequence in such a short time? That is where Wims comes in.

It uses powerful generators to translate an educational intention into readily usable interactions.
This talk explains how it works, and why it is not possible for so many powerful applications to be packed in a single widely distributed proprietary product.

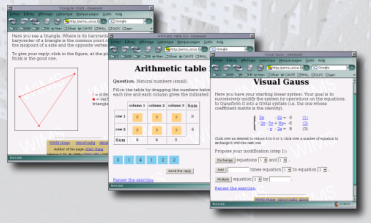
Ever found an interesting server for educational exercises? Not just drills, and quizzes, etc. I mean something really interesting, something you want to use for more than a few minutes.



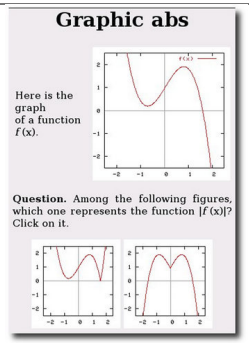
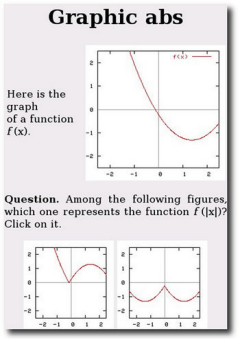
If you have, Wims is a better one.

Go to a Wims site like `http://wims.unice.fr/wims` (many mirrors are available), and have a look at these examples:

Example for the domain...	**Keywords for the search engine**
Interactive geometry	triangular (select the first hit)
Elementary arithmetic training	arithmetic table (select the first hit)
Algebra, at a higher level	gauss (select the first hit)



Let's imagine two students who are in neighboring seats, each with their own computer. They are trying to get a good score in a module dedicated to absolute values in maths.
They are given exactly the same exercise.

Here is what Dean sees	Here is what Clea sees
	

As the challenge is important, Dean asks Clea: Where should I click? Clea considers his neighbor's display, and says: **Click left**. So Dean understands and gets a good first score. Unfortunately, the teacher configured the exercise to ask the same question many times. As the second figure appears, Dean asks Clea Where should I click? and gets the same answer: **Click left...** So now Dean is sure to be on the right path, and when the next question comes along, he clicks left without asking, and again it's the correct answer. Unfortunately for Dean the correct answer for the fourth question is *not the left hand figure*.

When Dean shouts Oh what a stupid exercise! ...

... Clea considers the display, and says **Dean, don't you know?**
An absolute value must always be positive!

$$|f(x)| >= 0, \forall x.$$

Now let's consider the situation: after a few seconds, the two students come to make a verbal exchange at a very high level: **An absolute value must always be positive**! shows a mathematical rule, which is a highly cognitive object. Clea does half of the teacher's work.

When students collaborate on a Wims exercise, they cannot exchange information at low level. So they communicate high-level topics, doing half of the teacher's work

A little later, Dean might ask more questions, but organizing a racket to steal useful answers from clever students is impossible: even clever students are forced to study each individual case before giving an answer.

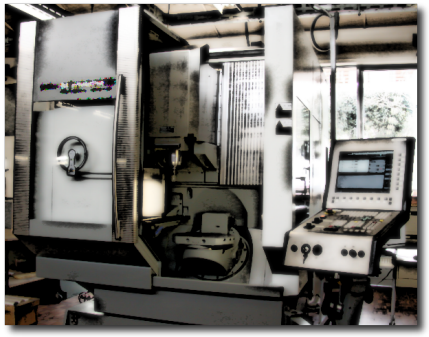
Communicating knowledge at a high level is the only possible way.

When you get under the Wims hood, you discover powerful engines Wims is built on top of a Unix or GNU/Linux system, which favors communication between processes.

The official mirrors of Wims currently use the following engines:

- **Maxima** a Computer Algebraic System which is often compared with proprietary programs like Maple and Mathematica.
- **Pari-GP** yet another Computer Algebraic System. Its specialty is the theory of numbers, polynomials and rational fractions.
- **Gap** , a Computer Algebraic System specialized in the group theory.
- **Gnuplot** for rendering 2D and 3D plots.
- **Imagemagick** which enables converting series of images to animations
- **Povray** to render algebraic surfaces by ray-tracing
- **Chemeq** a converter of flat chemical notations to LaTeX, which can perform various verifications and calculations.
- **TeX** to render algebraic formulas.
- **Units-filter** which parses the physical quantities.
- **Flydraw** a quick and efficient tool to create dynamic images.

However Wims is not limited to this rich set of applications: you can add every other application able to communicate with Wims. The only requirements are to be able to get parameters in the environment string, and to output either text to the standard output or data in a particular file.



For example, graphics have to be output as files named insert1.png, insert2.png, etc. Imagemagick allows you to deal with a variety of graphic formats, including JPEG, GIF, animated GIF, PNG, and MNG.
As another example, WIMS takes advantage of existing free libraries usable in dynamic web pages, as

DynAPI3 a javascript Library to generate DHTML layers, such as draggable areas, etc.

GeoGebra a fully interactive Java-based dynamic geometry tool.

Jmol a sophisticated Java Applet to view 3D molecule models.

... and many more.

Here we reach the main point of this talk: how can so much wealth be contained in one product, which can be run even on more modest configurations? If you're searching for a CAS (Computer Algebraic System) for your students, there is nothing cheaper than $100.
How is it possible to have the same thing on-line, with more features, open to thousands of students at the same time?

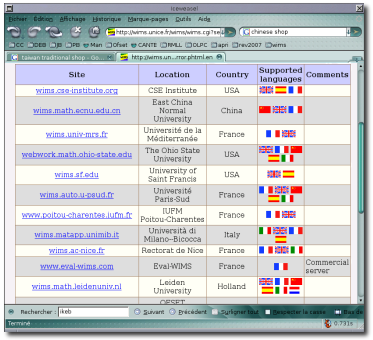
The availability of the source code makes it possible to write wrappers that ensure correct collaboration. Adding a new feature to Wims is just a matter of shaping a new glue component, which can be very simple.

WIMS is a Magic Server. That's because Wims is free software, using existing free software programs.

Let's consider the proprietary way. Very few companies can afford to control programs of such varying specialties as graphics, mathematics, physics, chemistry, and so on, at the same time.
A product gathering this many state-of-the-art applications covering such a variety of domains would imply expensive agreements between different companies, each having to make profit, and concerned by the possibility of diffusion of its knowledge.
With such rules, complex software products often become more expensive than the sum of their component parts.

Now let's consider Wims: it contains a glue engine, able to integrate any application under Unix or GNU-Linux. It is linked to the independent programs, each of which is written by specialists. The current set of components for this glue engine totals roughly 3 MB, whereas the satellite applications sometimes three times as large. With the most powerful satellite applications, no change was made to the code. The availability of the source code makes it possible to write wrappers that ensure correct collaboration. Adding a new feature to Wims is just a matter of shaping a new glue component, which can be very simple. You can use loads of pre-developed specialized software.

You can open a new Virtual Class for your students and assign them worksheets, in a matter of minutes. First find a Wims mirror near you: every Wims site has a link to official mirrors, and the first web site on the list, managed by the author of Wims, Gang XIAO, may be less responsive, particularly when the students of the University of Nice (France) have an exam.

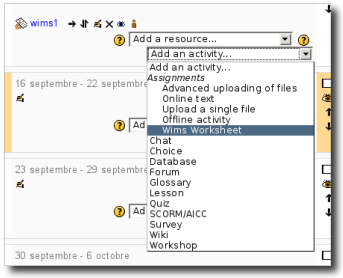


Site	Location	Country	Supported languages	Comments
wims.cse-institute.org	CSE Institute	USA		
wims.math.ecnu.edu.cn	East China Normal University	China		
wims.univ-mrs.fr	Université de la Méditerranée	France		
webwork.math.ohio-state.edu	The Ohio State University	USA		
wims.af.edu	University of Saint Francis	USA		
wims.auto.u-psud.fr	Université Paris-Sud	France		
www.poitou-charentes.iufm.fr	IUFM Poitou-Charentes	France		
wims.matapp.unimib.it	Università di Milano-Bicocca	Italy		
wims.ac-nice.fr	Rectorat de Nice	France		
www.eval-wims.com	Eval-WIMS	France		Commercial server
wims.math.leidenuniv.nl	Leiden University	Holland		

... Then follow the link to the teacher's area, and another link to create your class. You fill in a form with your name and your e-mail address, you then choose passwords for you and for your class, and you will be given control of a new Virtual Class: just watch your mailbox.
Once your class has been created, you can assign worksheets to your students: a worksheet is a collection of exercises picked in the pool of exercises from the web site. Most of the exercises are configurable, and you can configure the scoring features (severity, importance of the questions, etc). Then you assign the worksheets to your students, who can access them after an authentication step. You can create the students' accounts yourself, or let your students self-subscribe (they will need the password of the class, not your personal password).

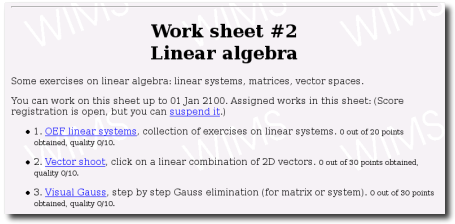
Moodle is a widely-used Course Management System, distributed under the free license GPL.
I have added a module enabling Moodle to embed Wims classes. Every administrative task (creating classes, authenticating users, gathering marks) is taken in charge by Moodle. Currently, collaborating Moodle and Wims services need to run on the same machine.

Wims worksheets are available as a subclass of Moodle's assignments.



The assignment appears to the students as an online text, with a special button, which pops up a Wims window. When the Wims window is closed, the marks got by the student are immediately synchronized with Moodle.

A Wims Virtual Class can contain worksheets, course documents and exams. It has a forum featuring a rendering engine for algebraic expressions
You can also add exercises of your own, created by the easy authoring interface. A Virtual Class features Course documents, easy to link to exercises or interactive demonstrations, worksheets can be used as exams: then strong anti-cheating mechanisms are activated.


Work sheet #2
Linear algebra

Some exercises on linear algebra: linear systems, matrices, vector spaces.

You can work on this sheet up to 01 Jan 2100. Assigned works in this sheet: (Score registration is open, but you can suspend it.)

- 1. OEF linear systems, collection of exercises on linear systems. 0 out of 20 points obtained, quality 0/10.
- 2. Vector shoot, click on a linear combination of 2D vectors. 0 out of 30 points obtained, quality 0/10.
- 3. Visual Gauss, step by step Gauss elimination (for matrix or system). 0 out of 30 points obtained, quality 0/10.

Enter a virtual class that you have created prior. Once you are authenticated, you enter the main page of the class, and there is a link to create new worksheets. Give it a title and a description, then add exercises you require by cycling through the following steps:

1. Go to main page of the class, and use the search engine to locate relevant exercises.
2. Follow a link given by the search engine, configure the exercise (qualitative and quantitative attributes), and test the exercise.
3. Once the exercise conforms to your requirements, put it in your worksheet (use the link at the bottom of the exercise to insert it).
4. Configure the subtitle of the exercise, the required score (so students must repeat the exercise to reach the score), the weight of the exercise in the worksheet.

Wims new exercises can be authored in two formats: the **Modtool** format, which gives access to any feature of the Wims engine; and the **OEF** (Open Exercise Format) format, featuring less flexibility, but very easy to use. The OEF format has powerful primitives, which make sense to teachers: \statement, \choice, \reply, \step, etc.
There is also an assisted composer for the OEF format, which is usable on-line, it's the Wims module **Createxo** (follow the link simple interactive exercises at the bottom of the main page of each Wims server).

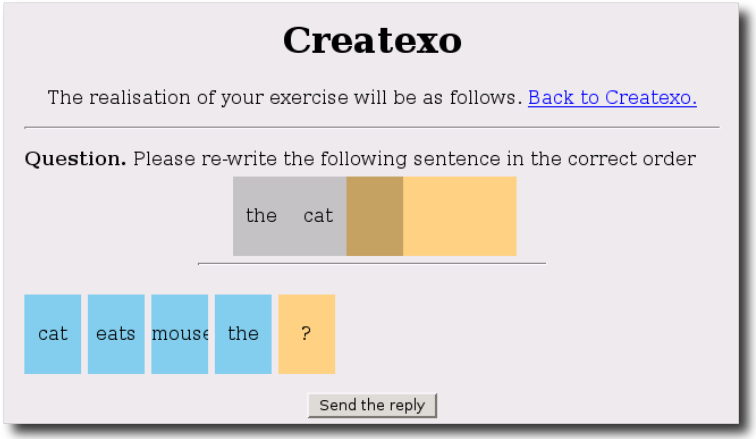
My first exercise in action, after submission

Here is the OEF source:

```
\title{My first OEF exercise}
\author{Clever Cleverer}
\email{clever@ofset.org}
\license{GPL V.2}

\integer{x1=random(1..9)}
\integer{x2=random(10..19)}
\integer{prod=\x1*\x2}

\statement{A rectangle has a width of
\x1 cm and a length of \x2 cm
calculate its area}

\reply{The area ...}{\prod cm^2}{type=units}
```

Type this text into CreatExo's facility for uploading sources (raw mode).

The second exercise in action



Here is the OEF source, which can be used a template:

```
\title{Template for clickfill EOF exercises}
\language{en}
\author{MARKEY Benoit}
\license{GPL V.2}

\text{phrase1 = the,cat,eats,the,mouse;
the,cloud,hides,the,sun;
what,time,is,it}

\text{phrase = randomrow(\phrase1)}
\integer{i = items(\phrase)}

\statement{Please re-write the following sentence
in the correct order
<center>\embed{reply 1,50x70x\i}</center>
}

\reply{reply}{\phrase}{type=clickfill}
```

There is very little customization required, just modify the lines which define the variable *phrase*.

The magic of \reply

The primitive \reply{...}{...}{type=...} is part of the magic of Wims. According to the type of reply expected, one of the powerful analyzers used by Wims will be triggered. Next is a table showing some examples of replies, which are returned if you indicate the right response type.

What Wims can understand, depending on reply's type

The input	**can be understood as ...**
`2+3/4`	2.75 (operations can be performed if the configuration allows it)
`2+3/4x`	$2 + 0.75 * x$ (symbolic formula can be processed)
`R I`	The same symbolic value as $R*I$, $I*R$, $R*I^2/I$, etc. It could be about the law of Ohm, $U = R*I$.
`1.5e-2 V`	0.015 V, the same meaning than 0.015 Wb/s or 0.015 W/A. The underlying engine knows the International System of Units.
`1h30min5s`	5405 seconds. Hybrid notations are taken in account.

`1,2,3`
`4,5,6`
`7,8,9`
	The mathematic matrix with 3 rows and 3 columns (which has a null determinant)

`2H2+O2 ->H2O`	The chemical equation $2H_2 + O_2 \longrightarrow H_2O$, Wims can check that it is balanced (it is not).

Wims can use powerful randomizers to output statements

Depending on the randomization strategy, the database of questions for one exercise can easily contain some dozens or many millions of different items.

Keyword	Meaning
Randchar	Returns a random char taken from a string
Randfile	Returns a random record taken from a text files. Records are multi-line texts.
Randint	Returns a random integer belonging to an interval or a list
Randitem	Returns a random item from comma-separated list
Randline	Returns a random line from a multi-line text
Random	Returns a random floating number belonging to an interval or a list
Randword	Returns a random word from a phrase
Shuffle	Makes a random permutation from a list (options can be specified to choose the parity of the permutation)

Powerful input strategies

In addition, there are fast and powerful tools to combine such randomized data in order to produce coherent exercises, such as evaluators for algebraic expressions, simplifiers, formatters for physical quantities (taking in account a precise number of significant digits), plotters, image generators, etc.
A set of script libraries add interesting features, like a graph-paper widget to train students about data analysis, enhanced input fields to write easily chemical equations, interactive areas to input vectors with the cursor, etc.

Multiply your efficiency by 20

Wims enables you to output effective on-line exercises very easily and quickly for yourself and it's worth sharing these exercises with the community. If there are twenty contributors of equal skill in such a community, each of them can author 5% of the contents, and each can benefit from 100% of the product. In addition, this collaboration often increases the quality of the output, as members want to make their contributions to be perfect. Another beneficial side effect is that bugs are more quickly detected and corrected by a group of contributors.

The mailing list

The mailing list for Wims can be subscribed to on the Wims subscribe page:
`http://listes.hosting.citic74.fr/wws/info/wims`.
Its information is displayed in French, but many of the messages are in English, so read the archives.
Wims enables you to output effective on-line exercises very easily and quickly for yourself and it's worth sharing these exercises with the community

Wims was created by Gang Xiao, who teaches mathematics to first year students at the University of Nice (France). As a consequence the most developed exercise pool is for mathematics, however you can now find an increasing number of exercises in hard scientific fields (physics and chemistry, etc). Many of the exercises can be used for other fields and most exercises authored using other tools can be translated to the OEF language.
You can visit his homepage at
`http://wims.unice.fr/xiao/xiao.html`

A subset of Wims can be made compatible with widely accepted standards like SCORM, still a work in progress. However Wims has a unique possibility, which obeys another standard: making software open to human understanding and using open source and free licenses. Other compatibilities have been tested, however at small scale: mathematic exercises not referring to graphics are accessible to blind people, provided they are taught to understand the TeX notation, which is used for any ALT attribute when algebraic formulas are displayed as images. This is also an ongoing work.

Install your WIMS server

Why install a Wims server, when you can just access other ones on-line?
The reasons for this include: increased responsiveness (the transactions are made on a faster bus), independence from other events (for example the server of a university may be less responsive to external solicitations when students are having exams inside), and hosting custom modules (making extra modules searchable or publicly visible requires the acceptance of the web master).

I know three methods to quickly install a Wims server in your school, typically within half an hour:

- Knowims
- Freeduc-Science
- Debian or Ubuntu packages

Knowims and Freeduc-Science are CD-ROMs based on the Knoppix distribution, the first one is customized by Gang Xiao, the second by the OFSET association. Both feature a testable WIMS server without installation, usable in your LAN five minutes after booting. They can be used to make a quick (half an hour) installation of a WIMS server. However the server will be sub-optimal in that case.

If you already have some services provided by a Debian or Ubuntu GNU/Linux platform, installing the packages for Wims is quite straightforward: just type "apt-get install wims", and your server will be ready to use a few minutes later.
As I maintain the Wims package for Debian, Ubuntu's package is published usually a few weeks after my updates in Debian. You may find more recent packages in the non-official Debian repository of OFSET.

- If the e-learning project you want to run contains exercises, Wims can do it better.
- It's free software, so it can be improved.
- If the graphical interface is not as nice as the interface of your preferred web site, please consider contributing to a Cascading Style Sheet (CSS), Wims already supports them.
- If you dream about a feature you never saw implemented, please contact the author of this talk, so we can discuss its feasibility, the glue engine of Wims is not that complicated.

Have fun

Now, if you want to impress your friends, invite them on a tour of a Wims server. Just use its embedded search engine and type one of the following example keywords (Google won't work, Wims is a web site with an infinite depth, so it blocks web spiders).

- shot
- country
- figures
- animated
- polyray
- vision

Have fun!