Evaluation of scientific disciplines in Moodle 2

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Moodle has some elements that provide for randomness for the online assessment and some limited support for math contents. But the teacher who wishes to work on real mathematics reaches the boundaries of Moodle 2 regarding maths and sciences rather early.

WIRIS quizzes for Moodle 2 is a tool designed to provide full support for the online assessment of scientific subjects, directly on the module Quiz. With *WIRIS quizzes*, the teacher can create questions with random parameters and graphs which are ideal for independent learning. Besides, the students get a visual formula editor compatible with mobile devices to introduce their answers. Finally, the teacher doesn't need to waste his or her time grading randomly generated exercises, as the system automatically evaluates math answers.

WIRIS quizzes for Moodle 2 includes important enhancements of the module Quiz also with respect to the previous version for Moodle 1.x. Most importantly, the teacher can easily specify the format of the student's answer by means of a series of simple assertions, such as: the answer must be simplified, or factorized, or expressed in physical units, or have a numerical accuracy of 3 digits, etc. On top of that, *WIRIS quizzes* integrates our latest formula editor, compatible with mobile devices thanks to its Javascript technology. This formula editor also provides real-time syntax check of the answer in order to minimise the insertion errors.

Finally, all WIRIS tools are specifically designed for education, so we keep a very alert eye on usability and feedback from our users.

1. Motivation

Our experience proves that random elements are highly appreciated by authors and teachers. From avoiding plagiarism to allowing an indefinite practice of a single exercise, the effort of introducing random parameters is easily justified, especially in scientific and technical fields such as maths, physics and chemistry.

The automatic evaluation of answers is a key element in random question systems. The integration of a calculation engine or CAS (Computer Algebra System) enables automatic correction and, at the same time, saves time to authors through a compact mathematical programming.

After a first stage of *WIRIS quizzes*, in which we collected and analysed lots of users' comments, it was clear that mathematical power was not the only core element of the system, but also the capacity to predicate on the format of the answer. In other words, it was important to say not only "The answer introduced is mathematically equivalent to the correct answer", but also "The answer is factorized" or "The answer has been given with an accuracy of 3 decimals".

Finally, the system interface is a key element for the cycle to complete successfully. Too often the correct answer is not reached due to technical problems, not mathematical. *WIRIS quizzes* approaches this issue from two perspectives: offers the student a visual formula editor and integrates a real time syntax check of the answer, with which the student detects easily if the answer given to the exercise contains any typo.

2. A basic principle: mathematical answers

Both if the question posed to the student has a closed format (multiple choice, matching, etc.) or if it has an open format (short answer, nested answers, etc.), the first step is that the answers can contain interesting mathematical values.

In a "Multiple choice" question, the scientific author is interested in having the chance to introduce complex expressions in each option without wasting time. Defining this kind of expressions in *WIRIS quizzes* is very simple with the definition of mathematical expressions with *WIRIS editor*.

But *WIRIS quizzes* expands its power when the format of the question is open, where the student must write an answer instead of choosing it on a predefined group. In this case, there is a huge amount of expressions that simply cannot be written without a built-in formula editor. The example of the following figure is very simple and obviously could be described with less beauty by using the conventional keyboard, but it is not difficult to imagine what happens if the answer to an exercise is a system of equations.

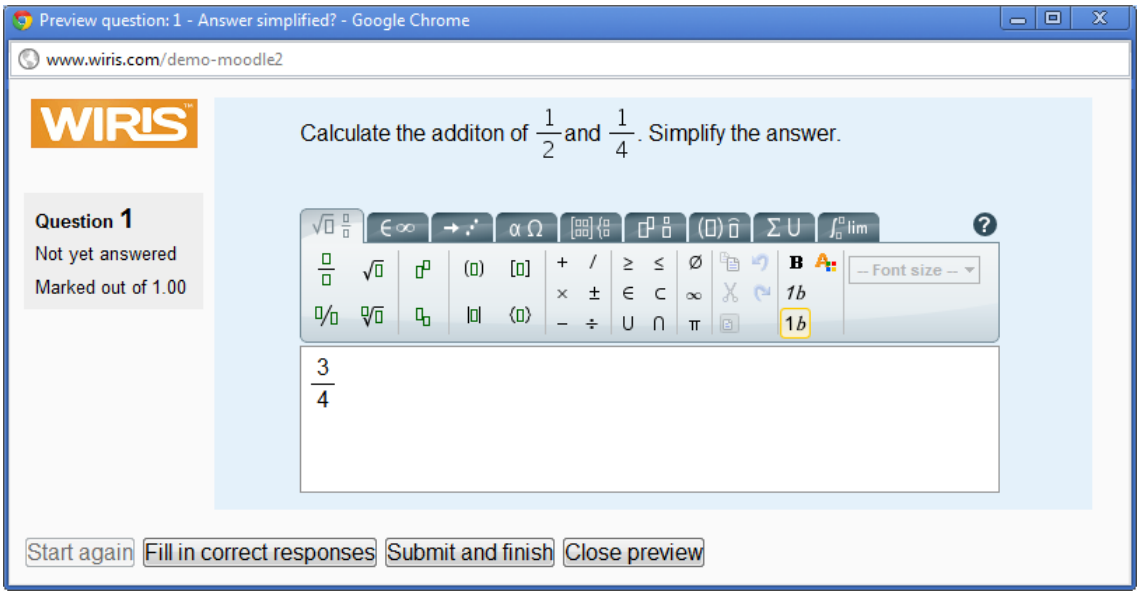

Figure 1

3. Automatic syntax check of answer

In case of open format questions, that is, when the student must write himself/herself the answer, we add to the mathematical difficulty the chance of a typo, such as an additional parenthesis.

WIRIS quizzes provides support to users in three different levels. On the one hand, the introduction of the answer is visual, that is, the student sees the answer that he/she is about to evaluate, and can detect spontaneously any mistakes in the expression.

On the other hand, the introduction of double symbols, such as parentheses, can be done with a single click, with which the risk of forgetting one parenthesis disappears if it is created with the button instead of the keyboard.

And the most important tool is the *Automatic syntax check*. This tool inserts an orange sign on the symbol that is blocking the expression. With this, the student is free to send the answer, but is aware beforehand that it will not be right, since it is not a mathematically correct expression.

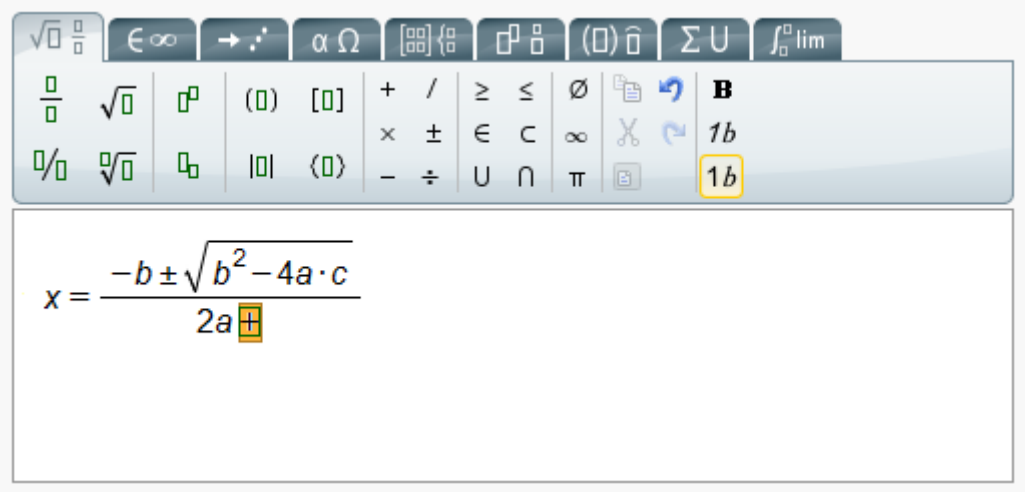

Figure 2

4. Predicates on the mathematical format of the answer

The second important element with which *WIRIS quizzes* enhances the functionality of *Quiz* module is the control of the mathematical format of the answer. By mathematical format we mean the features of the possible answer, such as:

- if the answer must be simplified, or factorized
- if the answer must consist of a polynomial, or a fraction, or a rational function, for instance
- if it must be expressed with a certain precision
- if it must be expressed in some specific units, such as cubic hectometres

- if it must contain a unit equivalent to that of the correct answer
- ...

At first sight it might seem trivial, but let's see how important can the format be with a small example. We imagine the question: “Factorize number six”. In this case, guaranteeing that the teacher's answer and the student's answer are mathematically equivalent would be enough, since number 6 is equivalent to its factorization, but it is not a correct answer. We need a higher control, by which we specify that the answer must be factorized. Thus, 2·3 and 3·2 will both be correct answers, while 6 will not. This simple example shows how important the format of the answer can be.

To further detail what we can predicate on the answer, the following figure shows these predicates as presented to the author of contents.

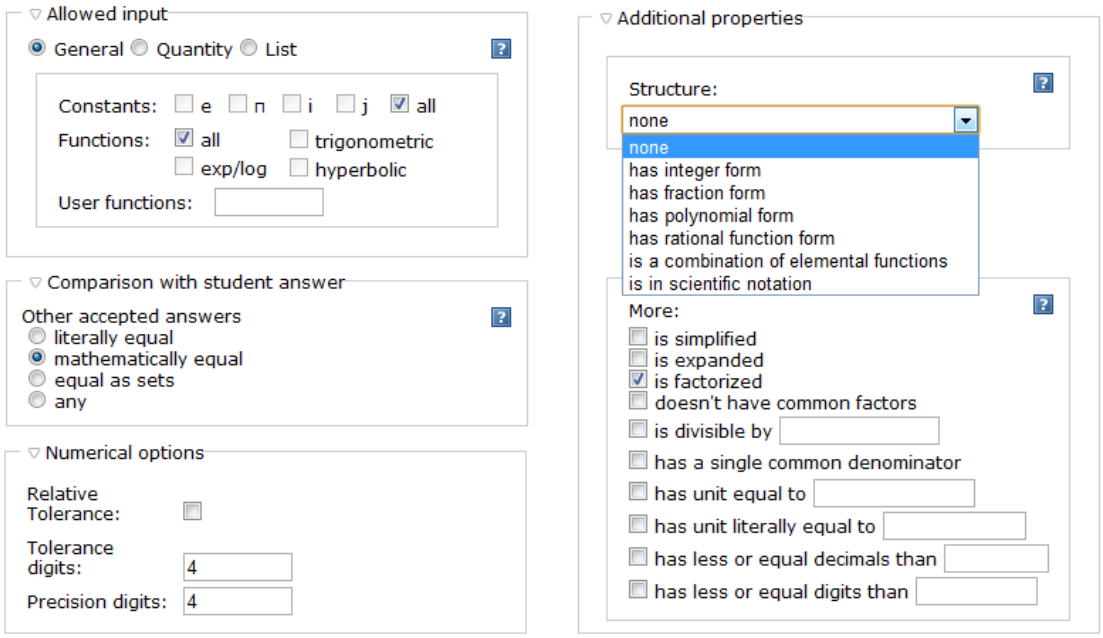

Figure 3

The authors can check whether they have parameterized the exercise as desired without the need to make simulations in student mode, since *WIRIS quizzes* includes an answer format check view. In it, the author can see how the system will perform if the student inserts a specific answer. Let's see it with an example in the following figure.

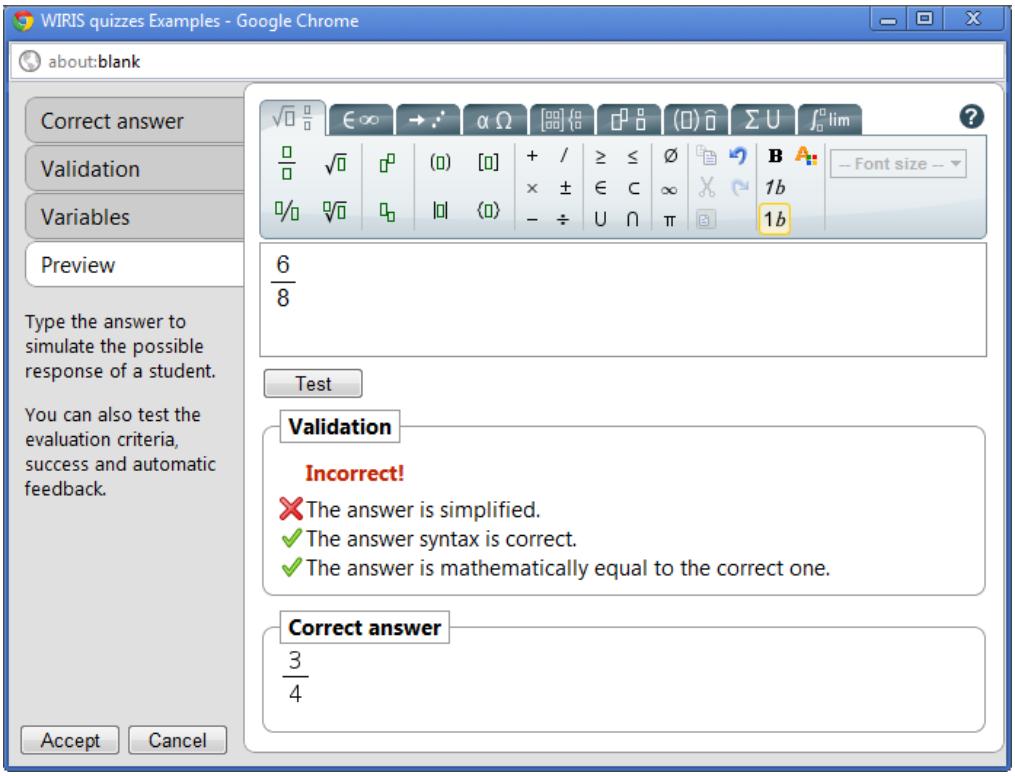

Figure 4

5. Questions with random parameters

In order to access all *WIRIS quizzes* power, we must go deep into its complexity. The most powerful element in *WIRIS quizzes* is the creation of random questions. These questions gather together all previous properties and functionalities, adding also randomness.

We will see in an example how randomness is coded in *WIRIS quizzes*. To do so, we must create a WIRIS-like question and define some variable in the *Variables* field. The *Variables* field contains a session of *WIRIS cas* calculator, a formal calculation engine that will allow us to exploit its mathematical power to benefit *WIRIS quizzes*. Let's see the look of this screen in the following figure.

Leaving aside the lower section, that allows *localizing* the tool, that is, defining how certain mathematical details are expressed, which tend to be expressed differently in different parts of the world, the tab contains:

5.1 *WIRIS cas* toolbar

5.2 *variables* section in the yellow box, where the parameters that we need for the exercise are defined

5.3 a section under the yellow box that we can use as a test area to see which values adopt the variables in different executions of the random algorithm

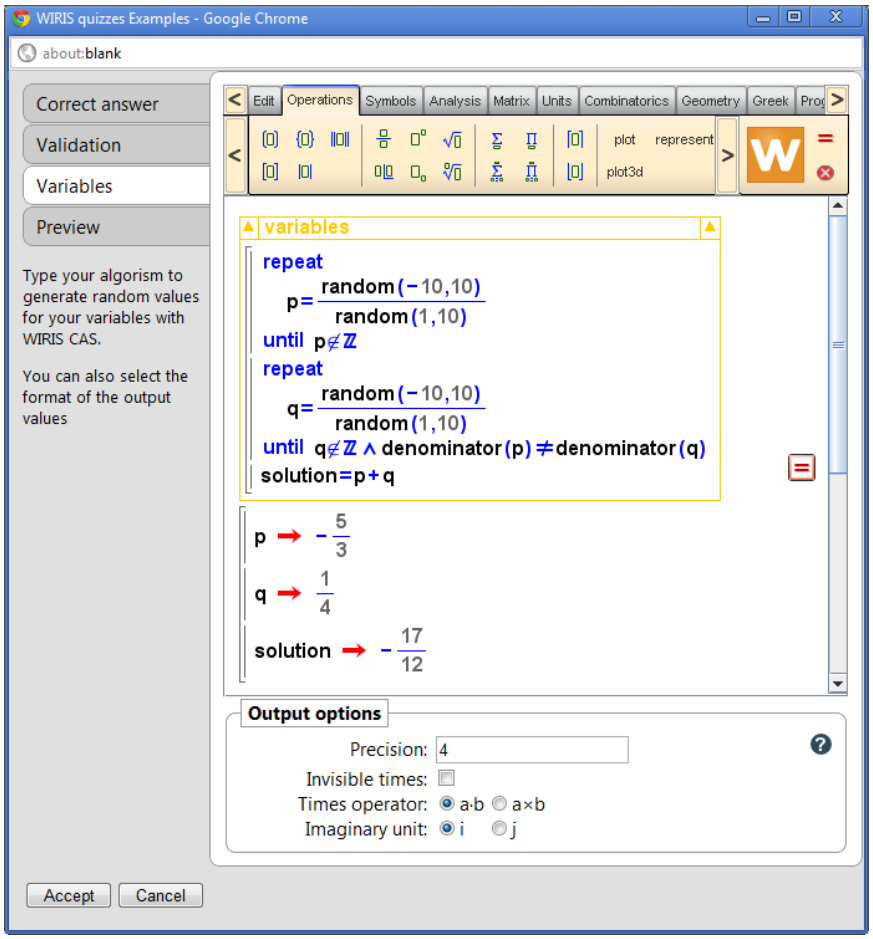

Figure 5

Let's see with more detail this example, in order to broaden our knowledge of the *random* command, that is always responsible of the generation of random scientific questions.

p is defined as the quotient between two random integers, the first one being an integer between -10 and 10, and the second a positive natural number smaller or equal to 10. With this, we ensure we will never divide by 0. Besides, since WIRIS is a mathematical language, we can insert commands such as $p \notin \mathbb{Z}$, that is, p is not an integer, but a fraction. With this, we ensure all students obtain exercises with similar difficulty, since two fractions will always have to be added up.

In this example, and it is usually like this, the difficulty consists in generating random parameters that verify the properties we need. Once it is done, solving the problem is trivial: $solution = p + q$.

But let's go back to *random* command. In the previous example, the command acts on a rank of integer values. This is the first way to work the command: given two integer values, *a* and *b*, it returns an integer in the rank *[a,b]*.

The command works similarly for two real values: given real *a* and *b*, it returns a real value in the rank *[a,b]*.

The third and last way of generating randomness is through a list of elements. The same command can include a list of mathematical elements, such as some functions: {sin(x), cos(x), tan(x), ln(x), e^x}, and will return one of them at random.

Only with this command, we will be able to generate all the complexity of mathematical questionnaires. We are going to see an eye-catching application of this command: random graphics.

6. STEMcollection.com free exercises

The content database is hosted at **STEMcollection.com**. Today, this collection contains more than 4500 questions, and displays a great trend to contain exercises from different levels and science subjects: ranging from courses for students with learning disabilities, a specific course for optics and optometry students, math courses for high schools and first university years.

The collection of contents is based on the principle of shared work and is offered under the licence desired by the content's author. Up to date, all teachers have decided to share their work for free under a Creative Commons licence. In order to simplify the location of contents, we have also created a Drupal-based user interface.

The exercises in WIRIS collection can be used in two different ways. If Moodle is not available or students will not be evaluated, they can practice directly on WIRIS collection web site, since the URL for each exercise is permanent and can be referenced in forums or emails. On the other hand, if we wish to know the results obtained by students, we can download the exercises for free and without logging in, to integrate them afterwards in our own Moodle. For this, installing WIRIS tools will be necessary. These tools are commercial, but are also available online for download and free test without authentication.

Apart from student and download mode, WIRIS collection users can see the exercise setup, whether to check that the algorithm performs what we expect from the wording, or to take ideas that help us develop our own content. This way, not only resources are shared, but also the technical capabilities that permit to create them, stimulating at the same time creation and adaptation.

Authors obtain recognition for their work on the right side of the exercise, as well as the institution in which contents have been created. This information can be hidden or displayed through the button appearing on the top right corner of the page, as shown in the following figure.

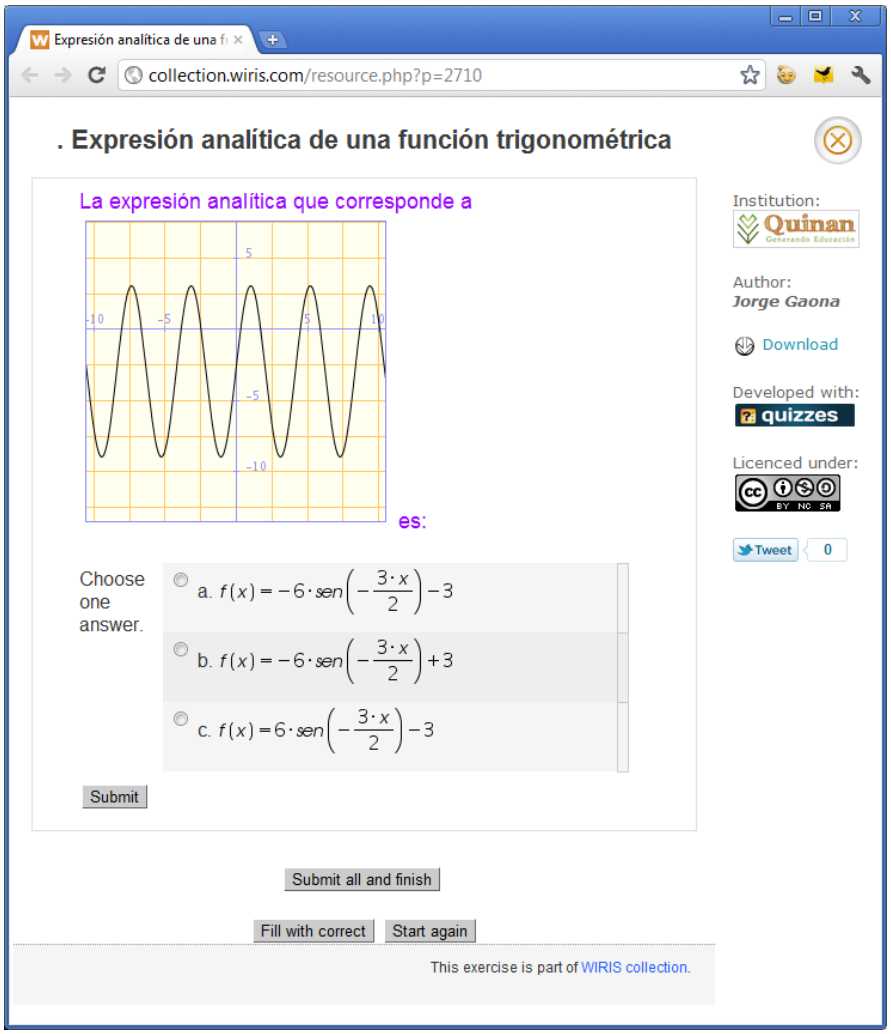

Figure 6

7. Conclusions

WIRIS quizzes is today a mature tool, that permits a broad range of possibilities to the creator of mathematical content. We have made an important effort to ensure *WIRIS quizzes* approach is not invasive, although it provides important improvements to Moodle's functionality.

With *STEM collection*, we have made available to users an important amount of contents that will simplify the use of *WIRIS quizzes* to expert users, but also, and most important, to teachers less skilled in new technologies, who will be able to reuse their colleagues' work directly or adapt it to their own needs. We hope that, making a collection of ready-to-use resources available to all teachers, some of them will find the motivation to start using ICTs in a simple manner. Overcoming the initial effort by reusing existing content, maybe they will gradually become modifiers and finally, creators of new contents for their students.