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### Abstract

We have used LON-CAPA for computer-aided assessment of problems in mathematics and computer science for several years and are now in the process to migrate to Moodle. We developed the tool LC2Mdl that allows half-automatic migration of several types of LON-CAPA problems to Moodle STACK XML files. Both systems allow randomization and use Maxima as the computer algebra system in the background. In LON-CAPA most parts are written in Perl which is not supported by Moodle in any way. So, fully automatic migration is not possible. Usually, you will have to do additional work by hand. But LC2Mdl saves a lot of time in this migration process.

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## Half-Automatic Migration of LON-CAPA Problems to Moodle STACK

Kilian Dangendorf<sup>1</sup> Frauke Sprengel<sup>2</sup>

**Abstract:** We have used LON-CAPA for computer-aided assessment of problems in mathematics and computer science for several years and are now in the process to migrate to Moodle. We developed the tool *LC2Mdl* that allows half-automatic migration of several types of LON-CAPA problems to Moodle STACK XML files. Both systems allow randomization and use Maxima as the computer algebra system in the background. In LON-CAPA most parts are written in Perl which is not supported by Moodle in any way. So, fully automatic migration is not possible. Usually, you will have to do additional work by hand. But *LC2Mdl* saves a lot of time in this migration process.

**Keywords:** LON-CAPA; Moodle; STACK; LMS; Maxima; Perl

### 1 Introduction

Computer-aided assessment in mathematics requires much effort in thinking about and writing good questions. Here, “good” means whatever you think of a good question. If you have a bunch of good questions, you want to use them in your courses. These questions exist inside a learning management system (LMS). If you need to change to another LMS, you usually need to rewrite all your questions for the new system. The idea behind these questions will stay the same, but the implementation differs according to different systems. The migration by hand would require rather monotone and repetitive work. For migrating questions from LON-CAPA to Moodle, we decided to write the program *LC2Mdl* which does this monotone and repetitive part. Some additional work after the automatic conversion is needed in most cases anyway. In the following, we describe why and how we did the migration and what the migration tool can be used for.

### 2 Starting into computer-aided assessment with LON-CAPA

LON-CAPA is a LMS with a focus on automatic assessment in mathematics and physics [Ko01].

In 2008, we started to use computer-aided assessment in mathematics in our pre-courses for individual formal assessment. This was only possible with massive help from the colleagues

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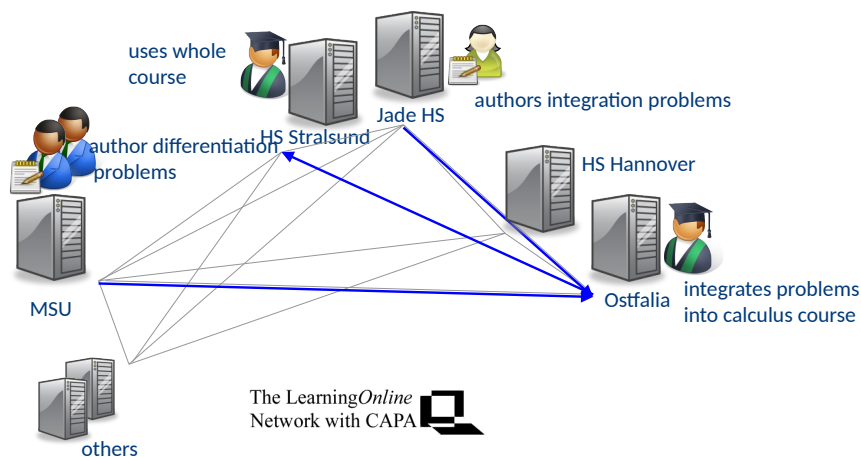


Fig. 1: LON-CAPA network<sup>3</sup>.

from Ostfalia University of Applied Sciences and other colleagues from Lower Saxony [Be09] and around the world in the LON-CAPA network.

In the network, authors can publish their questions at several levels - 1) only for use in their own courses, 2) for their domain (the server of their home university), 3) for the world - with or without the source code. Many authors publish their questions world wide. Course coordinators can assemble their courses using questions from many different authors. This is done by a clever combination of references and local copies. This way, you have always the newest version of the question in your course. Course coordinators can allow other people from the network to clone their whole courses. So, reuse of resources is possible at several levels as can be seen in Figure 1.

So, the start with LON-CAPA was rather easy. Over the next years, we have developed our own questions and run the mathematical courses of our department in LON-CAPA. We contributed to the large shared LON-CAPA resource pool containing about 300,000 questions in 2018<sup>3</sup>. Programming LON-CAPA questions is highly flexible. You can combine several input- and test-types in one question, implement in Perl and Maxima, randomize variables and graphics, use the student's answer in later parts and give specific hints depending on wrong answers.

We used the questions mainly for homework by the week and for individual preparation for the final written exams at the end of the term. We experienced positive effects from the possible immediate feedback to the answers given by the students.

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<sup>3</sup> Cf. [www.loncapa.org](http://www.loncapa.org)

### 3 Moving to Moodle with question type STACK

LON-CAPA was used only for a few mathematical courses and only in our department. All other courses at our university use Moodle. So, the students in our department had to use two different LMS and complained about the rather old-fashioned look and feel of LON-CAPA. Not only the look was rather old. We had to face the problem, that there were no longer updates for the system. So, the main reason for leaving LON-CAPA were security issues.

At that time, our central E-learning service already supported the Moodle question type STACK [SG06] on our Moodle server. Only very few courses used it, and almost nobody had some experience in writing their own questions. So we had a lot of good mathematical questions available - but not for STACK.

Converting all questions from one system to the other completely manually never was an option due to the lack of time and experience with STACK. But at a department of computer science, there are other options. A Bachelor's thesis [Da19] with a prototype was our starting point to develop the conversion tool LC2Mdl [DS21].

### 4 Comparison of Question Programming

Programming questions in LON-CAPA and in STACK have a lot of similarities and of course some differences.

We start with the similarities. Both systems

- store their questions in a special XML,
- use Maxima as the underlying computer algebra system,
- use MathJax for displaying  $\text{\LaTeX}$  formulas in texts and HTML elements for formatting,
- use Gnuplot for displaying dynamically created function graphs and other graphics
- support multilingual questions,
- can handle multiple parts with using student's input in former parts,
- can mix all possible input and test types in a single question,
- can give special feedback to frequently made errors,
- allow randomization almost everywhere.

Differences important for conversion are for instance

- most programming parts in LON-CAPA are in Perl with no equivalent in Moodle,

- LON-CAPA stores images in the author space, Moodle somewhere in a course.

Some more things can be done in LON-CAPA but not in Moodle STACK such as

- parts solved step by step (not showing the next part, before the first wasn't solved),
- including "libraries" for code or parts shared among several questions,
- mixing essay parts with other parts,
- conditional blocks depending on question variables or the student's answer to former parts,
- randomizing the order of options in all types of multiple-choice questions.

## 5 Conversion Tool

As mentioned, both LMS work with XML, but in different ways. Moodle uses the *data-centered* XML<sup>4</sup> as a well-structured data container as it is usually used for data exchange. LON-CAPA problems come in a *document-centered* XML. Question texts and active script parts are ordered as they should be displayed and executed. This is comparable to an HTML document.

For instance, in a LON-CAPA problem with two consecutive tasks, there are at least one Perl-script, one text, one response (input field), another text and another response. To match Moodle's data-centered XML, we have to accumulate the single fields into one question variables and one question text, containing well-positioned links to the input fields.

After reordering, we had to decide whether and how to convert the different elements of LON-CAPA questions.

### 5.1 Response Types

We analyzed quite a number of questions and found out, that in our courses, we used the response types *math*, *formula*, *numerical*, *string*, *radio button*, *option*, *match*, *custom*, *essay* (also for file upload), *external* and *image*. Other response types as *rank*, *functionplot*, (chemical) *reaction* and *organic* are never used in our questions. Despite the fact, that there is an XML scheme for LON-CAPA XMLs, certain variations are possible. So, we decided to omit response types that we don't know and cannot test.

*External* is a type for responses that have to be graded by an external grader. STACK does not support this. We will use *Grappa* [GHW15] for coupling Moodle to the external grader.

<sup>4</sup> Beside XML, there are other import-formats, but XML is the recommended one (cf. [https://docs.moodle.org/37/en/Import\\_questions#Importing\\_questions\\_from\\_an\\_existing\\_file](https://docs.moodle.org/37/en/Import_questions#Importing_questions_from_an_existing_file)).

*Image* response is meant as “click into the image” for (dynamically created) images. This can be realized by STACK questions using JSXGraph. The underlying programs are very different and we have only a few such questions. We decided to write new questions instead and omitted this type for conversion, too.

The response types *formula*, *numerical* and *string* are scalar types with direct equivalents in STACK (*AlgEquiv*, *NumAbsolute* resp. *NumRelative* and *String*). The response type *math* uses a Maxima algorithm to grade the student’s answer which can (more or less) directly be used in STACK’s feedback variables.

The multiple-choice response types *radio button*, *option* and *match* can be realized via the STACK input types *radio* and *drop down list* and need the generation of some extra Maxima code for storing the options into Maxima variables. Since the lines in questions with drop down lists cannot be randomized in STACK, we included the option to realize option response questions with only two options as radio button questions.

Stand-alone *essay* response type questions with no randomization are converted to the Moodle question type *essay*. All other essay responses are converted into two questions combined sequentially in one quiz – the first one is a STACK question and the second one is an essay question. The feedback is shown in the STACK question because there it can be randomized.

The grading of *custom* responses is done by a Perl algorithm. This has to be converted into Maxima and goes into STACK’s feedback variables.

## 5.2 Feedback, Parts, Blocks, Images and Multilingual Questions

In LON-CAPA, the authors can use conditional hints to give feedback to frequently made mistakes. They are of the same structure as the corresponding response type described above. We converted them into parts of the potential response tree in STACK.

Multiple parts (also with using the student’s answer in later parts) are possible in both systems. The difference is: in LON-CAPA, you have an input button per part, in STACK you have only one for the whole question. In LON-CAPA, you can show the question by parts and decide when to show the next part (e. g. first part solved or no more tries available for the first part). We lose this in STACK.

Conditional blocks in LON-CAPA questions may depend on a “normal” variable, or on the student’s answer in a former part, or on the status of a former part (e. g. solved) or . . . . We try to support this by conditional parts in STACK’s question variables and question blocks<sup>5</sup>. This may or may not work in the converted question.

<sup>5</sup> See Question Blocks in documentation of STACK: [https://docs.stack-assessment.org/en/Authoring/Question\\_blocks](https://docs.stack-assessment.org/en/Authoring/Question_blocks)

Questions may contain images. Since we want to have only one XML file to import in Moodle, we decided to include the images as SVG into the XML. If you store the SVGs in Maxima variables, you even can randomize over a list of SVGs. LON-CAPA questions may contain dynamically generated images made with Gnuplot in a certain XML format. We can convert this into Maxima code because Maxima's plot is also based on Gnuplot. Maybe, not all possible options are supported in STACK.

We support multilingual questions using Moodle's *Multi-Language Content Filter*<sup>6</sup>. For doing so, we had a hard fight with LON-CAPA's backward compatibility which allows several realizations of translated questions. We have full support for English and German. If you need other languages, some short intermediate texts are needed in some places. Please contact us about this.

### 5.3 Handling Perl

Since STACK uses Maxima, we tried to map frequently used Perl snippets on the corresponding Maxima code. Starting with variable assignments and simple functions, we implemented step by step our control structures conversion<sup>7</sup>. Tailored for our question set (most from mathematics) it handles most of the conditions (if, elsif, else, unless), loops (do, while, until, for) and operators (e. g. ++, %=, etc.). Contents of literal strings and comments will be preserved by further replacements and are converted into Maxima. Functions commonly used in maths are replaced by their Maxima equivalent possibly by reordering the parameter list. These conversions are mostly done by matching regular expression references and context-sensitive character search (e. g. find closing bracket at balanced parentheses).

Libraries can be used in LON-CAPA for parts repeatedly used among several questions. They can contain everything allowed in a LON-CAPA problem and can be nested, but most likely they contain Perl. While converting, we first just include the whole content into the question itself and start conversion afterward.

Since Perl is a powerful programming language (i. e. Perl Compatible Regular Expressions) there is no chance for a whole equivalent in Maxima. But for small calculations, this conversion gives clear results. The longer the script the higher the probability to fail. To arrive at a conclusion: 100% conversion is not possible and you have to expect that.

## 6 Known Issues

If there are images in a question, the conversion produces rather long SVG strings. If they are stored in variables, your STACK server may have difficulties to handle these

<sup>6</sup> Moodle Plugin Multi-Language Content Filter: [https://docs.moodle.org/310/en/Multi-language\\_content\\_filter](https://docs.moodle.org/310/en/Multi-language_content_filter)

<sup>7</sup> Overview on how we convert Perl-script into Maxima: [https://github.com/kiliandangendorf/lc2mdl/blob/master/perl\\_conversion\\_overview.md](https://github.com/kiliandangendorf/lc2mdl/blob/master/perl_conversion_overview.md)

kind of questions due to time outs. Until now, STACK cannot handle multilingual parts in multiple-choice questions<sup>8</sup>. We can produce them, but they will not be displayed correctly. Since the concepts of Perl and Maxima are rather different, the converted programming parts have to be inspected rather carefully. For instance, Perl *arrays* always start with index 0 and don't need to be initialized while Maxima *lists* start at 1 and need initialization.

## 7 Migration Workflow

Now, we discuss how the actual migration of a LON-CAPA problem to a STACK question should work. Here is the algorithm:

1. If it is not your own LON-CAPA question, please ask the authors of the question, whether they allow migration and re-publishing in STACK. Since many authors already published their questions with source code available to the LON-CAPA community, most of them will allow this.
2. Get the source code of the problem out of LON-CAPA.
3. Run the program LC2Mdl on a single question or on a directory with questions, libraries and images.
4. Edit the Moodle XML of the question in a normal text editor. The use of the Moodle question editor is horrible at this stage. Depending on the question, this may take five minutes to one day. It may also happen, that you choose to make a completely new STACK question with the same idea.
5. Load the Moodle XML into Moodle and hope for the best. If you did not change the XML structure while editing, Moodle should accept the file.
6. Open the question for editing, click “save changes and continue editing” and edit until STACK and you are satisfied.

Following this, migration of about 20 homework problems per week was possible in parallel to the last corona terms. Depending on the given question, you may have less or more work to do with editing the converted question. You will see everything from “no editing necessary” to “just the question text is how it should be”. Some things have an easier realization in Perl/Maxima (LON-CAPA) and some things have an easier realization in Maxima alone (STACK).

In summer term 2020, we asked some students who knew both systems for their impressions. They liked the modern look and feel and having all their courses and deadlines in one LMS. Nobody mentioned the validation in STACK. This is quite astonishing because they

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<sup>8</sup> Cf. issues regarding multilingual problems: [https://github.com/mathsmoodle-qtype\\_stack/issues?q=multilang](https://github.com/mathsmoodle-qtype_stack/issues?q=multilang)

often complained about LON-CAPA (which shows input mistakes only after submitting the answer). In the first term of running STACK in our courses, there were several complaints that STACK runs too slow. Before, only one or two smaller courses used it. Now, Maxima got a bigger server to run on and the responding time is much better.

## 8 Summary

LC2Mdl can be used to convert many types of LON-CAPA questions into STACK questions. We provide good support for conditional hints, multilingual question texts with  $\text{\LaTeX}$ , HTML and variables, images (as SVGs), Gnuplot plots, Maxima programming parts, multiple-part questions, and simple Perl programming parts. We partially support longer Perl programming parts (requires some editing), conditional blocks, the combination of STACK parts with essay parts, and multiple parts using the student's answer. LC2Mdl does not support (and never will) elaborated Perl libraries, the use of external tools in randomized problems (e.g. JFlap), questions with multiple parts step by step, and very special types of problems. Our converter LC2Mdl is available under GPL on GitHub [DS21].

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