Towards intelligent learning environment for medication calculation within ALM project

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Eleaga_ e-learning games

Abstract

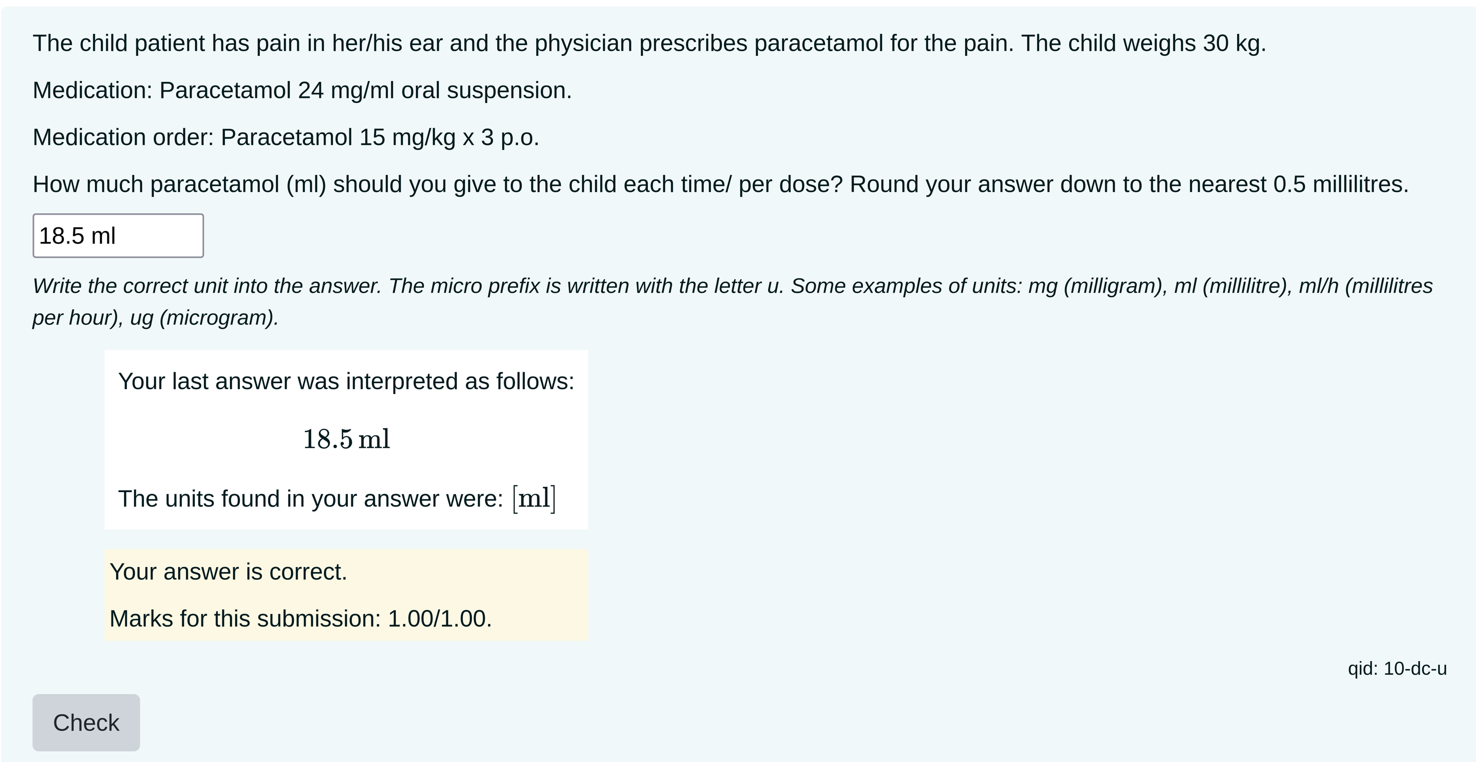
An e-learning environment ALM (short for "Arcada LäkeMedelräkning") for teaching medication calculations has been developed as part of Ministery of Education funded "Älyoppi" project in 2018-2021. A teaching experiment has been carried out on ALM at Arcada, and the results will be reported in a forthcoming article.

The purpose of this presentation is to outline emerging prospects of the novel e-learning technology *Stateful* for general mathematical content that could be used for improving ALM. Such improvements comprise, e.g., introduction of more expressive game-like features, enhanced student interactivity, and new possibilities in learning analytics. At the moment, *Stateful* is experimental technology by **Eleaga Ltd Oy**, and it is being pilot tested in various areas of STEM teaching in Aalto University and elsewhere.

Background

The challenge of dosage calculation is that the outcome resulting from even a minor error in basic arithmetics may pose a serious threat to patient safety.

To respond these challenges, a pilot version of the digital learning environment ALM has been developed for healthcare students and professionals to practise and maintain their skills. This version of ALM has been realised using classical STACK technology [4, 5] as a Moodle question type. ALM currently provides students automatically assessed, randomised, and personalised exercises that are suitable for independent practising of medication calculations outside the classroom. Furthermore, ALM is able to analyse the way how a wrong answer is wrong, and it gives immediate, taylored feedback and the final score.


The child patient has pain in her/his ear and the physician prescribes paracetamol for the pain. The child weighs 30 kg.

Medication: Paracetamol 24 mg/ml oral suspension.

Medication order: Paracetamol 15 mg/kg x 3 p.o.

How much paracetamol (ml) should you give to the child each time/ per dose? Round your answer down to the nearest 0.5 millilitres.

18.5 ml

Write the correct unit into the answer. The micro prefix is written with the letter u. Some examples of units: mg (milligram), ml (millilitre), ml/h (millilitres per hour), ug (microgram).

Your last answer was interpreted as follows:

18.5 ml

The units found in your answer were: [ml]

Your answer is correct.

Marks for this submission: 1.00/1.00.

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Check

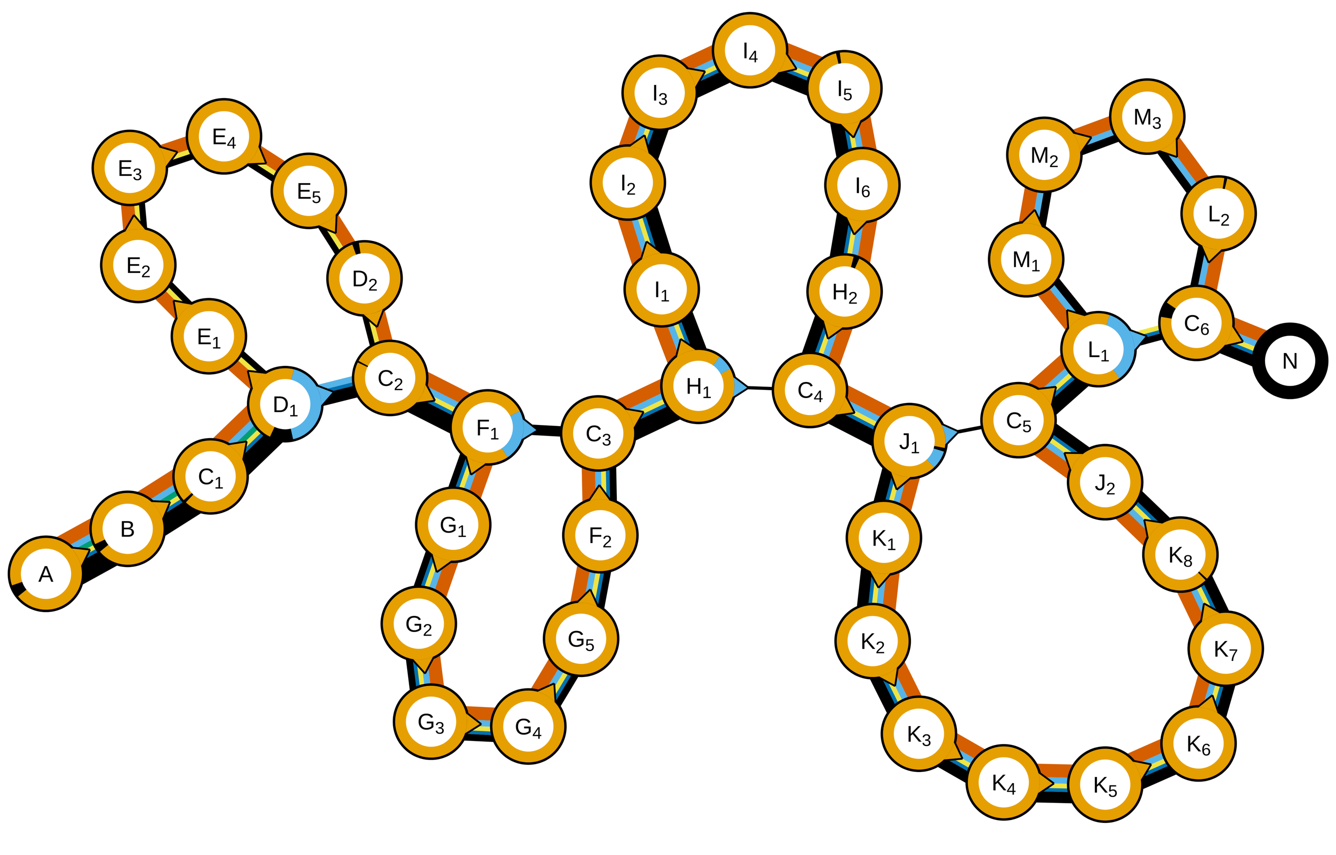
The pedagogical background of ALM is the 4 Cs teaching model for medication calculations [2]. In this model, the mathematical proficiency is divided into four areas of competence: (i) **C***omputing* skills, (ii) ability to make unit **C***onversions*, (iii) understanding to **C***onceptualise* the problem, and (iv) being able to **C***ritically evaluate* the outcome. This classification has been validated as a basis for manually categorising the students' errors in medication calculations in [1]. This success makes it plausible that even automatic error categorisation could be possible if the data produced by the e-learning system is rich enough. Such classification is useful for making the e-learning system more intelligently adapt to each student's specific needs.

The current version of ALM is a 2 Cs system since it only supports the computing and unit conversion aspects of the 4 Cs model [3]. To produce a 4 Cs system for medication calculations, requirements for the underlying e-learning technology are quite demanding. The novel e-learning technology *Stateful* appears to be able to meet at least some of these requirements based on ongoing research in, e.g., teaching university level physics. An exercise realised in *Stateful* produces great amounts of data from students' actions, and it can be processed by data science algorithms to reveal new knowledge about the student population and the learning process in general.

The purpose of this presentation is to outline the possibilities of *Stateful* for teaching medication calculations according to the 4 Cs model by [2], using the lessons learned from the ALM project as background [3].

What does *Stateful* really do?

Stateful is an extension of the classical STACK question type by providing it an *internal state* and true *inner-loop adaptation*. As such, the power of expression of *Stateful* is comparable to rogue-like game engines that were popular in 1980–1990's.



As an example of a *Stateful* exercise for learning thermodynamics of Diesel engine from Harjula et al. (2021, ongoing work). The topology of the exercise is the *road of five review loops* from the start scene A to the end scene N. The colours indicate the different routes the students went through the scenes in the teaching experiment.

The main features of *Stateful* are as follows:

1. A *Stateful* exercise is a linked collection of classical STACK questions (i.e., *scenes*) that form a logical whole with a plot.
2. The scenes share and process common data so as to produce and keep up *situational awareness* in its internal state, involving all aspects of student's activity.
3. *Stateful* records all data about student's actions. The data can be used in *learning analytics* for profiling, e.g., problem solving strategies and challenges.
4. A *Stateful* exercise adapts itself to its situational awareness in an intelligent way. In future, adaptation even to student profiles from a *learning analytics* extension is possible.

Improving ALM to comprise all 4 Cs using *Stateful*

Teaching medication calculations at Arcada traditionally involves 11 different problem types. The student is given three different solution strategies to discover which one is the most suitable for herself (i.e., equations, proportions, dimensions).

As pointed out in [3], the current version of ALM on classical STACK is not suitable for teaching the dimensions *Conceptualise* or *Critically evaluate* in the 4 Cs model. Let us outline how *Stateful* could be used to improve ALM.

1. A *Stateful* exercise of the type *road of review loops* can be produced for each of these 11 problem types, facilitating all three solution strategies. Student's favourite strategy can be identified from the actions, and this knowledge can be used to adapt the system's reactions to student's needs on the fly.
2. The *Stateful* exercise could propose the same question with small variations to challenge the student's depth of understanding from different directions. Variations can be given in terms of, e.g., drugs, concentrations, doses, patient information, and units.
3. An element of surprise can be introduced in the learning path. The student may be asked to solve a problem in a way that is not her favourite. Furthermore, relevant "what if" questions can be included in random locations and at random times.
4. The student can be given irrelevant information in the problem statement that must be separated from what is relevant before carrying out calculations.
5. Insufficient information can be provided as well. The student should observe this and require the missing information to make the problem solvable. The student should be encouraged to adopt an active role where her own selections affect the course of the exercise.
6. The student can be asked to rate her self-confidence about getting the right answer at various stages of the exercise. The development of the reported self-confidence can be monitored.
7. *Stateful* gives intermediate results of student's score during the exercise in order to keep up the motivation.

How would you efficiently teach each of the Cs in 4 Cs by using, e.g., review loops in *Stateful*?

About error analysis

It has been observed in an experiment within university STEM teaching that the students can be profiled effectively based on their behaviour in the "road of review loops" type of exercise introduced above.

All data from *Stateful* can be automatically classified for learning analytics using, e.g., Self Organising Maps, or some other clustering or statistical algorithms. Considering the example on Diesel engine, the observed student behaviour seems to divide into three main clusters.

As opposed to teaching, e.g., thermodynamics, medication calculations are based on just four arithmetic operations applied to given numerical parameter values. Now the set of "possible solutions" can be generated, from which student's computations can often be reconstructed (assuming that the student did not make mistakes in copying numerical values).

Conclusions

We conclude that creating e-learning material for medication calculations in *Stateful* is demanding business. Experiences of a professional teacher are indispensable in the materials development. Once the materials have been piloted on students, new observations can be made from the accumulated data using data science tools.

Some pedagogical theory about the learning process is helpful in order to structure the *Stateful* exercise and to profile the student's mistakes for creating an efficient error handling logic. The 4 Cs model by Johnson et al. [2] seems quite suitable for this purpose.

References

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