Creating an automated learning environment for medication calculation: results from pilot experiments

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Challenges in learning medication calculations

The required skills are elementary arithmetics but

1. practical problems vary and are often ill-defined,
2. even a minor error in calculations may lead to patient injury or death,
3. not all students of healthcare professions are mathematically oriented, and
4. re-examination of registered nurses is required every five years.

It has been estimated that 700–1700 people die prematurely in Finland each year due to a mistake in medication.

4Cs model by Johnson & Johnson

S.A. Johnson and L.J. Johnson proposed a model for conceptualising the pedagogy of medication calculations in 2002.

This is the 4Cs model, describing four aspects of the learning process as follows:

1. **C**ompute,
2. **C**onvert,
3. **C**onceptualise, and
4. **C**ritically evaluate.

It was observed by **Dahl et al. (2014)** that 4Cs can be reliably used as a categorisation principle for students' mistakes in medication calculations.

Medication calculus is taught on the course "Läkemedelsbehandling och patientsäkerhet" in Arcada University of Applied Sciences.

Three main ways of learning:

1. Taking part in workshops in a classroom,
2. self-studying using lecture notes and old exams, and
3. practicing in the online learning environment **Sigma** in 2002–2016 and **ALM** in 2019.

The students take part in these activities at their own discretion. Nothing is compulsory.

However, the student is required to get 100 % correct result in the semester exam.

ALM is an e-learning platform that

1. is built on the automatic assesment system STACK for mathematical content . . .

2. . . . which functions as a question type within Moodle;

3. It is based on the experiences of the earlier in-house system Sigma at Arcada, and

4. its development was funded by the Älyoppi project of Ministry of Culture and Education in 2018–2021.

An exercise on dosage calculation in ALM.

What is in ALM?

1. 8 basic types of exercises appearing in medication calculations (unit conversion, dosage based on patient weight, concentration, etc.).
2. Drugs referred to by their generic name (active ingredient).
3. Numerical parameters for the exercises randomised so that the consentrations and doses follow the commercial products.
4. Localisation to Swedish, Finnish, and English.

The current version of ALM

1. classifies the wrong answer, given by the student, how it is wrong (both the numerical value and the unit),

2. gives immediate feedback, and

3. produces grading (which, however, is not rewarded in passing the course).

ALM, however, does not

1. profile students' performances...

2. ... and, hence, does not adapt to it.

Pedagogical experiment

ALM was tested in conjunction with the traditional teaching in Arcada in autumn 2019.

The experiment was carried out within the mandatory course for medication calculations and patient safety "Läkemedelsbehandling och patientsäkerhet" for first year students.

The purpose of the study was to obtain a big picture about learning medication calculations by combining classroom teaching with online learning.

A particular focus point was assessing the suitability of STACK for students of healthcare professions.

The pedagogical experiment consisted of the following parts:

1. Two questionnaires in LimeSurvey, the first one before the course ($N = 68$) and the second one after the course ($N = 54$).

2. The questionnaires comprise claims that the students are asked to evaluate on scale 1 (strongly disagree) ... 5 (strongly agree).

3. Data from the final exam (i.e., # of attempts) and full student action data collected in the ALM platform.

4. Statistical analysis carried out in SPSS.

5. Research ethical permission acquired following the conventions in Arcada.

Background data about the student population

1. 95 students took part, of which 88 were first year students.
2. The final exam was passed by 52 students on first attempt, 20 on the second attempt, 4 on the third attempt, and 5 on the fourth and last attempt.
3. 9 students did not pass the exam.
4. 5 students dropped out from the course.
5. 45 students had upper secondary school background out of those 68 students who answered the pre-course questionnaire.

Results on ALM

ALM was used by 39 students (N = 95).

Out of the 54 students who answered the post-course questionnaire

1. only 13 reported having used ALM even though . . .
2. . . . the records show that 29 of them had been active in ALM!

Furthermore,

1. High score in ALM (i.e., 7 . . . 8) has a statistically significant correlation with passing the final exam with a low number of attempts: $rs(39) = -0.423, p < 0.05$.
2. 95 % of ALM users ($N = 39$) passed the final exam on their first or second attempt, whereas 83 % of other students passed on their first or second attempt.

ALM was assessed useful with grade 4. . . 5 on scale 1. . . 5 in 81 % of students' answers.

Results on workshops

Out of the 54 students who answered the post-course questionnaire

1. 44 reported having taken part in at least one workshop. . .
2. . . . of which 77 % passed the final exam on first attempt.
3. The users of ALM took part in workshops more often but the difference is not statistically significant.

Moreover,

1. there is a statistically significant positive correlation between experienced support and reported investment on workshops: $rs(39) = 0.45, p < 0.003$.
2. Correspondingly, there is a statistically significant negative correlation between experiences support and lack of investment on workshops: $rs(39) = -0.76, p < 0.001$.

Workshops were assessed useful with grade 4. . . 5 on scale 1. . . 5 in 74 % of the students answers.

52 of the students (N = 95) answered the question about using paper, pen, and calculator.

Of these students:

1. 75 % always used paper and pen.
2. 50 % always used calculator.
3. 44 % used pen, paper, and calculator.

25 % reported having used ALM out of those who reported having used the lecture notes (N = 48) or old exams (N = 46), or both.

Digital and paper based learning methods seem to divide students.

Conclusions (1)

In general:

1. E-learning in medication calculations involves technological, pedagogical and students' orientation related challenges.
2. These challenges are different from those in STEM fields.
3. ALM is a rather demanding learning environment.

Considering the pedagogical model of **S.A. Johnson and L.J. Johnson**:

1. ALM is suitable for learning Compute and Convert aspects in 4Cs model.
2. Current version of ALM does not support learning Conceptualise and Critically evaluate aspects.

1. Reported value points in workshops: sociality, cooperation, encouragement, support.

2. Workshops are helpful for finding personal problem solving strategies.

3. The digital "Abitti" -system used in upper secondary schools in Finland may give an advantage for using e-learning environments.

4. It seems that students with upper secondary school background are better prepared for independent studies than others.

Conclusions (3)

Remarks on pedagogical practises:

1. ALM does not reduce teacher's workload.
2. Less drill training, more administration and material development.
3. Better focus of teachers' resources when classroom teaching is used in conjuction with ALM.
4. ALM is available 24/7, which is a value in itself.
5. Evaluating the students' starting level before the course would be advantageous.

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Thank you for your attention!