

Extreme Apprenticeship: teaching exact sciences in an experimental way

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- Extreme Apprenticeship courses in Helsinki and in Bolzano
- Lessons learned, student comments

Motivation

- Exact sciences, like Mathematics and Computer Science, are part of the curriculum in any Life Science degree programme – but students find them hard !!
- High dropout rate, poor grades, low retention of concepts in next courses
- Teaching is mainly based on lectures + some exercises
- Can we improve on such a situation?

Extreme Apprenticeship

- Based on Cognitive Apprenticeship: the focus is more on the process than on the end product
- Educating an apprentice by working under the guidance of a master, in order to acquire a skill
- Traditional example: a practical skill like shoe making
- Applied also to cognitive skills
- Instruction takes place in three phases:
 - modeling, scaffolding and fading.

XA phases: modeling

- Modeling phase: give the students a conceptual model of the task and let an experienced person show the students how the task is performed
- Lectures are based on worked examples, from beginning till end
- Teacher is thinking aloud to show the mental process behind programming

XA phases: scaffolding

- Students are solving exercises under the guidance of an experienced instructor
- Students are given just some hints to discover answers by themselves
- This is Vygotski's idea of scaffolding

XA phases: fading

- When the student is starting to master the task, scaffolding is dismantled gradually
- Students work on their own and improve further their skills and knowledge

XA and the role of exercises

- Exercises do not simply apply theory shown in lectures.
- Roumani says
 - *We think of them as teaching instruments that complement lectures by teaching the same material but in an exploratory fashion*
- Exercises take a crucial role in raising students motivation

Student motivation in XA

- Intrinsic motivation is better than extrinsic rewards
- Difficult exercises kill the motivation of weaker students
- Challenging exercises, and short term goals that can be achieved, raise students motivation
- Instructors feedback increases motivation
- Level of comfort increases motivation: it comprises self-esteem, and self-efficiency

XA Core values

- (1) The craft can only be mastered by practicing it. Skills to be learned are practiced as long as it takes, for each individual
- (2) Continuous feedback flows in both directions. The apprentice receives feedback on her progress, and the master receives feedback by monitoring challenges and successes of apprentices

Courses @ Helsinki

- Reduce the number of lecture hours (Traditionally: 30 hours, XA: 1 hour)
- Increase lab hours where students can find teaching assistants (8 lab-hours per week for 67 students)
- Increase the number of teaching assistants in order to have all students scaffolded and all exercises corrected (Traditionally: 252 exercises corrected by 5 teaching assistants for 140 students; XA: 17420 exercises corrected by 13 TAs for 192 students)

Pass rates @ Helsinki, CS

- Programming course non-CS beginners
- Programming course CS beginners

Traditional course average pass	XA course average pass
43.7%	70.1%

Traditional course average pass	XA course average pass
58.5%	71.3%

Mathematics @ Helsinki

- Math lab arranged (a room with writable surfaces: tables, walls...)
- Theory 2 hours a week, to recall exercise materials
- Traditional complex exercises replaced by step-by-step sequences of questions
- Reflective exercises requiring articulation
 - *"Explain in your words, without using mathematical symbols, the results of the previous task"*

Assessing Math courses

- Level of quality is significantly raised w.r.t traditional course
- Pass rates are comparable (80-82%)
- Student self-perception and course satisfaction is high (resp. 83% and 93%)
- A comment:

the best thing about the course was that I learned things the hard way. At first the demanded accuracy felt unreasonable but in the end I can say that it helped me to understand things more clearly and do them correctly

In Bolzano: OS lab

- OS is an 8-credit course at the Bsc, 3rd semester
- Typical intake is 40 students/year
- Course assessment: theory (50%) assessed with a written exam; lab (50%) assessed with project work
- Lab Part One (2 credits) has been given in 2011 with XA methodology

Self-assessment of students at the beginning

- Some students already knew the topic from high school
- Many students had no previous knowledge!

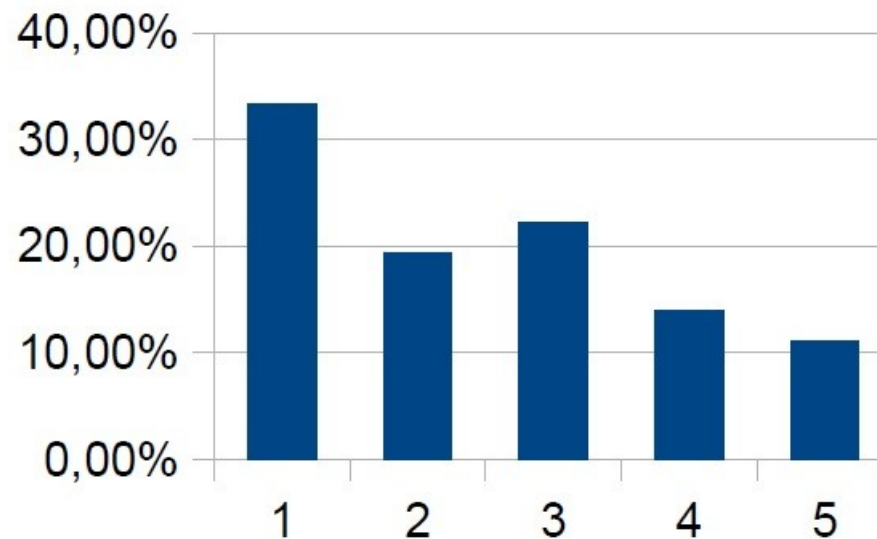
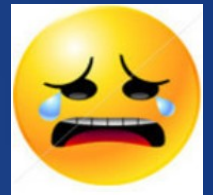


Fig. 1: Self-assessment of students' previous knowledge on Linux and shell scripting, in a 5-point Likert scale (1 no experience, 5 expert)

Lab organization

- Students are divided in 2 groups.
- Overall teacher availability in lab is 6 hours/week
- Lab is under the supervision of ONE person only (no simultaneous presence of teaching assistants)



- Blended format (exercises can be submitted from home, or from lab during lab hours)

Blended XA & Moodle

- The nature of the exercises does not allow for instant grading in lab
- Exercises must be submitted and assessed by teacher later on
- A Moodle instance is available and well known to students
- A Moodle wiki is used to give exercise materials
- Moodle is indispensable to keep track of the grades (overall more than 3100 exercises submitted by 44 students!)

Feedback to students

- An email is generated after each exercise is graded
- The student can see the comment, if any, from the teacher
- Comments explained mistakes (without suggesting corrections)
- Some comments were just warnings or emoticons
- Each student sees only own grades

Grades in Bolzano

- Comparing the result achieved at the FIRST of three calls for the 2011-12 exams
- In „Traditional“ we total the pass results of the past 3 cohorts in the first call of OS (101 students involved)

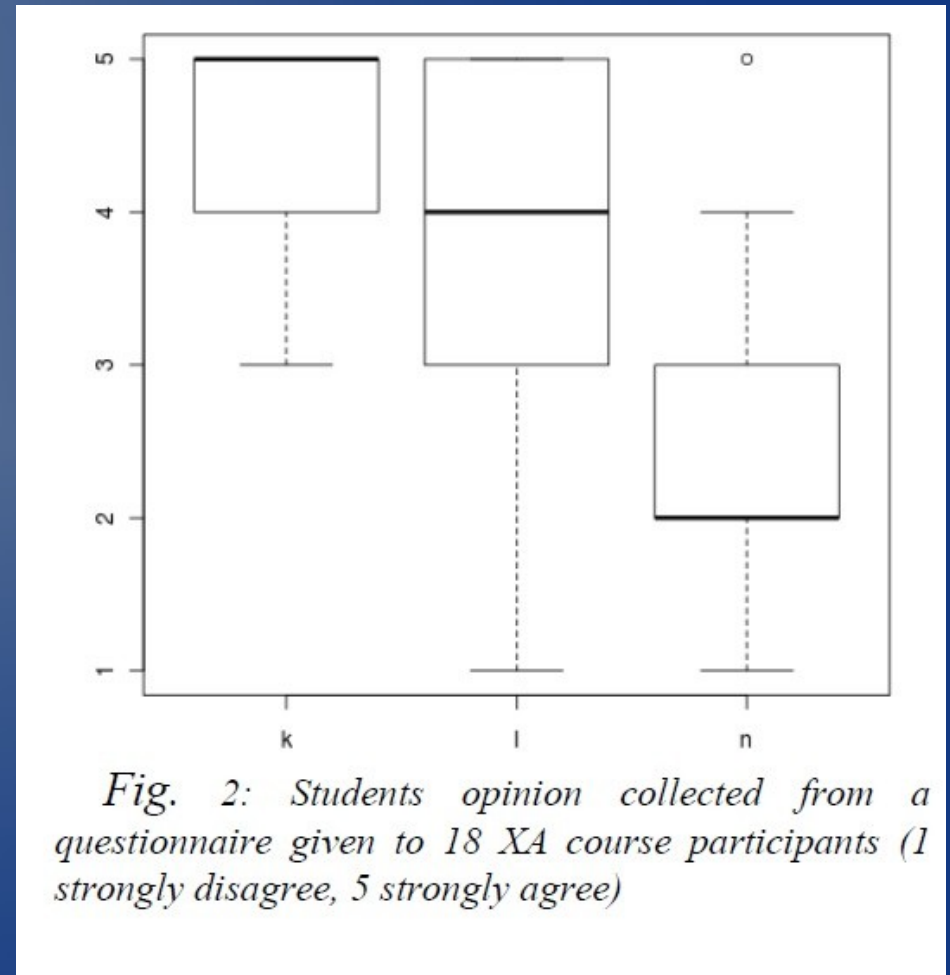
Traditional - passed	%	XA - passed	%
33	33%	22	52%

Lessons learned

- XA can become blended
- Students are generally happy with it
- Students learned a lot and were timely
- Students did not complain for spending too much time in doing exercises
- Drop-outs had personal reasons, no one was discouraged by the format
- Drop-outs from past years have passed the exam without difficulties

Student opinion and self-perception

- 1: Now I know the course topics
- 2: Lab gave me a better understanding of theory
- 3: Lab took me more time than expected



Student comments

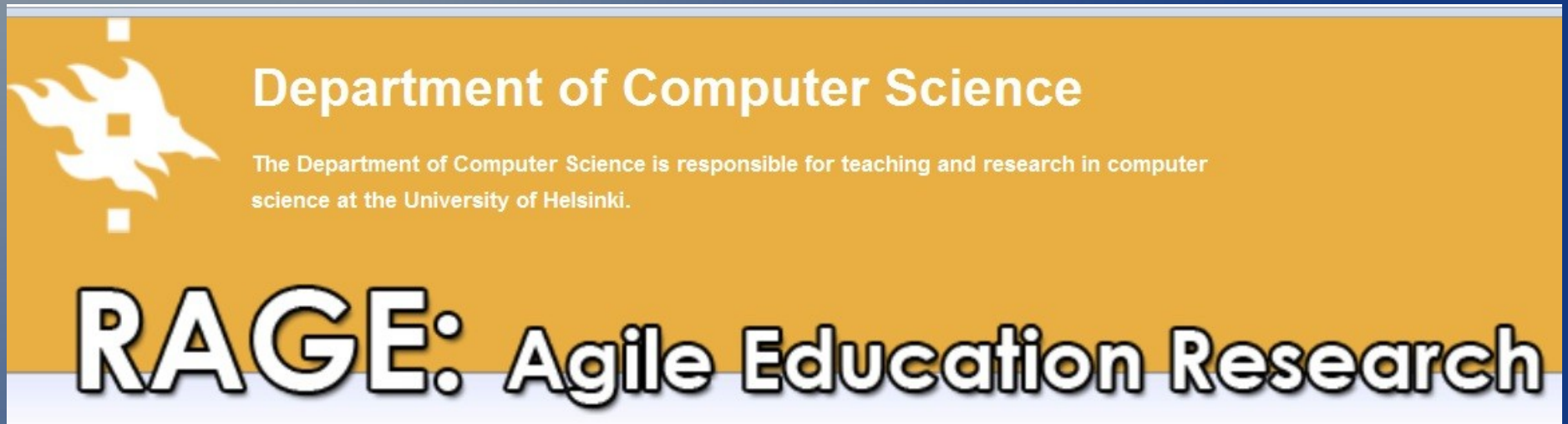
- From a student that self-assessed as poor:

This is new way of teaching. It is very interesting. I didn't expected from myself, that without any knowledge about bash and without any lectures, it is possible to learn so much!

- From a student that self-assessed as good:

writing a shell [a complex take-home activity] would have been interesting, but anyway writing this script was a nice experience

Acknowledgments



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<http://www.cs.helsinki.fi/en/rage/>
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gdodero @ unibz . it

