## Extreme Apprenticeship, a new way of teaching CS?

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#### HELSINGIN YLIOPISTO

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- Extreme Apprenticeship principles
- Extreme Apprenticeship practices in Helsinki
- OS Lab in Bolzano: main issues
- Supporting a blended lab with Moodle
- Lessons learned & Future plans

#### Motivation

- Learning how to program is hard
- High dropout rate, poor grades, bad habits emerging in next courses (like Data structures, or Programming Projects)
- Teaching how to program in introductory programming courses is mainly based on lectures + some exercises (home assignments, complex exercises)
- The problem is not in mastering syntax and semantics of a language, it is in mastering <u>the process of</u> <u>combining constructs into programs</u>

#### **Extreme Apprenticeship Principles**

- Based on Cognitive Apprenticeship: the focus in 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
- Robert Martin claims that mentoring newgraduates in the software industry should be achieved by constant and intensive guidance:
  - Software is a craft that takes years to learn, and more years to master. The only way to properly learn the craft is to be taught at the side of a master

#### 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 programming 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

 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

#### XA practices in Helsinki - 1

(1) Effectiveness of lectures in teaching programming is questionable; lectures should cover the minimum before starting with exercises

(2) Topics covered in lectures must be relevant for the exercises

(3) Exercises start early, right after the first lecture of the course. In the first week apprentices already solve an extensive amount of exercises: a motivational boost from course start

#### XA practices in Helsinki - 2

(4) Exercises are completed in a lab in the presence of masters scaffolding the instruction. There must be ample time to complete exercises while masters are present.

(5) Exercises are split into small, achievable tasks. The small intermediate steps guarantee that apprentices can actually see that their learning is progressing

(6)Exercises are the driving force, so the majority of exercises should be completed by most students

#### XA practices in Helsinki - 3

(7) The number of exercises should be high and even somewhat repetitive

(8) Exercises should provide clear guidelines, e.g. how to start solving the task, when is it considered finished

(9) Apprentices are encouraged to find out things by themselves beyond materials covered

(10) Best practices are emphasized in the scaffolding phase – they come at no extra cost

#### Course format in Helsinki

- Reduce the number of lecture hours (In Fall 2009 30 hours, in Spring 2011 just one hour)
- Increase lab hours where students can find teaching assistants (8 lab-hours per week for 67 students; 20 lab-hours per week for 192 students)
- Increase the number of teaching assistants in order to have all students scaffolded and all exercises corrected (in Fall 2009, 252 exercises corrected by 5 teaching assistants for 140 students; in Fall 2010, 17420 exercises corrected by 13 TAs for 192 students)

#### Course outcomes (Helsinki) - 1

Avg spring	Avg fall	2010 Spring	2010 fall
43,7%	58,5%	70,1%	71.3%

- Above numbers are the pass percentage of Introduction to Programming
- In Spring the programming course is typically taken by students of other disciplines
- In Fall the programming course is taken by CS students
- In spring number of students is much less than in Fall (2010: 67 vs 192)

#### Course outcomes-Helsinki - 2

Avg Fall	Avg Spring	2010 Fall	2010 spring
60,1%	45,3%	77,6% *	86,4%

- Above is the pass rate of the Advanced Programming course
- Typically those who fail introduction to programming tend to skip it
- It clearly shows that what was learned in introduction to programming is well remembered in the next course
  \*: the teacher did not follow XA practices completely, he used fewer exercises and same materials as in the past years

#### In Bolzano: organizing OS lab

- OS is an 8-credit course at the Bsc, 3rd semester
- It follows Computer Architecture, and precedes Distributed systems
- Typical intake is 40 students/year
- In first Bsc year, students already take an introductory and an advanced programming course, based on Java
- Course assessment: theory (50%) assessed with a written exam; lab (50%) assessed with project work
- Lab is divided in two parts, bash scripting (25%-2 credits) and scripting project (25%-2 credits)
- Bash scripting is supervised by teacher; project is supervised by TA.

### Bash scripting

- Goal: to be able to solve a nontrivial problem by a script
- Course content: textbook "Linux command line and shell scripting bible" by Blum and Bresnahan (Wiley 2011)
- Duration: 6 weeks (October-mid november)
- Methodology: <u>Blended XA</u>

# Self-assessment of students at the beginning

- In some high schools students already knew bash scripting
- Some students had never used the terminal interface



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

#### Materials

- Order of topics and exercises presented in the textbook are NOT useful for the XA approach
- Exercises were redeveloped from scratch using the XA guidelines (just-in-time information)
- Let's see examples of exercises from week 1 and from next weeks...
- Cyclic exercises that repeat over weeks (solve similar problems in different ways)
- Time to solve exercises for an experienced programmer around 1 hour; for a novice 4-6 hours

#### Lab organization

- Students are divided in 2 groups. Each group has 2 lab hours per week with teacher supervision (= 4 hours/week)
- Teacher has 2 office hours/week (moved to the lab)
- Overall teacher availability in lab is 6 hours/week (coherent with XA in Helsinki)
- Lab is under the supervision of ONE person only (no simultaneous presence of teaching assistants!!)
- Schedule: Tue 14-16, Wed 8.30-10.30, Thu 18-20
- More than half of students are daily COMMUTERS!!!
- Tendency to skip early/late schedules is not avoidable

#### Lab assessment rules

- Exercises must be delivered within a week
- Teacher corrects them giving feedback (especially for mistakes!)
  - Feedback is also given in real-time during the lab, raise your hand and teacher comes!
- One more week to submit corrections to wrong exercises
- Deadlines are strict, and exercises are many (53 in 6 weeks plus a few optional exercises)
- Typical grading is 0-1, pass-fail

#### Lecture organization

- Lectures cover different topics from lab (Silbershatz-Galvin-Gagne textbook)
- Lectures have a convenient schedule (10.30-12.30) and students <u>do</u> attend them
- Every week 20 minutes of "collective feedback"
  - What we learned in the lab (metacognitive reflection)
  - Popular mistakes, popular misunderstandings
  - Collective progress statistics (for motivation)

#### Blended XA ?!

- Blended is not contemplated by XA!
- Practice #4: Exercises are completed in a lab in <u>the presence of masters scaffolding the</u> <u>instruction.</u> There must be ample time to complete exercises <u>while masters are present.</u>
- Violating practices has proven suboptimal in Helsinki (a teacher violated practice #5 and result was poorer than expected)
- Can we provide enough scaffolding by <u>asynchronous feedback</u> to compensate Practice #4?

#### Blended XA and Moodle

- The nature of the exercises does not allow for instant grading in lab
  - Example: student writes /user/ownlogin/ instead of ~
- Exercises must be submitted and assessed by teacher later on
- A Moodle instance (www.teleacademy.it) is available and well known to students
- A Moodle wiki is used to give exercise materials

#### Course main page

1 cai 2011-2012	Operating Systems	
CASE-Teaching ► 1112-CS-OS		Switch role to • Turn editing on
People – <u>Participants</u>	Weekly outline	Latest News     Add a new topic
Activities - Assignments Forums Resources Wikis	<ul> <li>News forum</li> <li>Student Forum</li> <li>Exercises part 1 (bash scripting)</li> <li>Questionnaire on bash scripting</li> <li>Comments on written exam-first call</li> </ul>	25 Jan, 15:18 Nabil El Ioini Projects demo <u>more</u> 18 Jan, 14:29 Nabil El Ioini
Search Forums - Go Advanced search? Administration -	<b>10 October - 16 October</b> Lecture by prof Dodero on Oct 11 User and kernel mode Lecture by prof. Dodero on Oct 13	Projects demo <u>more</u> 28 Dec, 10:26 Nabil El Ioini Submit the complete Project all in one <u>more</u>

#### Delivering exercises for Week 2



Lecture by prof Dodero on Oct 11 User and kernel mode Lecture by prof. Dodero on Oct 13 OS functionalities and interfaces Chapter 2 Exercises for the second week solution ex.11 solution ex.12 solution ex 13 solution ex.14 solution ex 15 solution ex.16 solution ex 17 Feedback from second week

#### Wikis

#### <u>CASE-Teaching</u> ► <u>1112-CS-OS</u> ► Wikis

Week	Page Name	Summary	Туре	Last modified
2	<u>Exercises for the first</u> <u>week</u>	In this wiki there are the exercises for the first week of the course	Teacher	Wednesday, 28 September 2011, 02:08 PM
3	Exercises for the second week	Exercises for the second week	Teacher	Thursday, 6 October 2011, 07:13 AM
4	Exercises for the third week	Exercises for the third week	Teacher	Friday, 30 September 2011, 09:20 AM
5	Exercises for the	Exercises to be done in lab week 4	Teacher	Monday, 10 October 2011,

#### Giving feedback to students

1	<u>Marco Sacchi</u>	0/2 -	h		Thursday, 1 December 2011, 09:17 AM	<u>Update</u>	0.00
1	<u>Branko Sipek</u>	2/2 -	h.	<ul> <li><u>exercise48.sh</u></li> <li>Sunday, 27</li> <li>November 2011,</li> <li>09:46 PM</li> </ul>	Monday, 28 November 2011, 11:17 AM	<u>Update</u>	2.00
1	<u>Amit Solanki</u>	2/2 -	h.	Monday, 21 November 2011, 07:09 PM	Monday, 21 November 2011, 07:33 PM	<u>Update</u>	2.00
1	<u>Giuseppe Aina</u>	No grade 🝷				Grade	-
				10			
L	<u>Luca Barazzuol</u>	1/1 •		Friday, 28 October 2011, 11:05 AM	Friday, 28 October 2011, 06:04 PM	<u>Update</u>	1.00
L	Luca Barazzuol Benjamin Bauer	1/1 · 0/1 ·	Manages only one line of the file	exercise35a.shFriday, 28 October2011, 11:05 AMexercise35a.shTuesday, 8November 2011,08:11 PM	Friday, 28 October 2011, 06:04 PM Tuesday, 8 November 2011, 11:09 PM	<u>Update</u> <u>Update</u>	1.00

#### Feedback to students

- An email was 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

#### More on feedback

- Exercises were graded daily (at least once per weekend)
- Less than 24 hours between submission and feedback

<u>First name</u> / <u>Surname</u> 1	© solution Ex.8↓	© solution Ex 9	© solution Ex.10 ↓	© solution ex.11	solution ex.12	<b>solution</b> <u>ex.14</u>	solution <u>ex.16</u>	© solution ex 13	© solution ex 15 ↓	solution ex 17
Desmond Adjapong	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	1.00	0.00
Elona Agolli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<u>Giuseppe Aina</u>	-	-	- 1	(-)	-	-	-	-	-	-
Luca Barazzuol	1.00	1.00	1.00	1.00	1.00	1.00	3.00	2.00	1.00	1.00
<u> Benjamin Bauer</u>	1.00	1.00	1.00	1.00	1.00	1.00	3.00	2.00	1.00	1.00
Luca Bellettati	1.00	1.00	1.00	1.00	1.00	1.00	3.00	2.00	1.00	1.00

#### Course calendar

- To remind of deadlines, lectures, exercises...
- Deadlines were strict: no late submission was allowed

Calen	dar					-		
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	1	2	3	4	5	6		
7	<u>8</u>	9	<u>10</u>	11	12	13		
14	<u>15</u>	<u>16</u>	17	18	19	20		
91	0.0	0.0	0.4	25	26	07		
Thursday, 24 November events $\underline{X}$								
Ţ	Deadline sixth week							
Ĉ	solution Ex. 37							
	solutio	n Ex. 3	38					
	solution Ex. 39							
	solution Ex. 40							
	solution Ex. 41							
	solutio	n Ex. 4	<u>42</u>					
	<u>solutic</u>	on Ex. 4	<u>43</u>					

### Fading phase

- From week 3, students gradually moved to working from home
- Those who needed help continued to come to (inconvenient) lab hours
- In week 6, the teacher was attending a conference and all tuition was from distance
- Topic of week 6 (regular expressions) was difficult, more wrong submissions than ever
- No one failed for lack of tuition in week 6

#### Lab grades

- 100% correct submission: 23 students
- 90-99% correct: 5
- 80-89% correct: 3
- 70-79% correct: 1
- 60-69% correct: 3

Failed students must do an exercise (similar to those of weeks 5-6) during 30 minutes, together with the written exam.

#### Project grades:

- Very good: 5 students
- Good: 18 students
- Average: 7 students
- Sufficient: 6 students

#### Lessons learned

- XA can be blended with care!
- 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

- K: Now I know how to write scripts
- L: Now I have a better understanding on how OS works
- N: The lab took me more time than expected



Fig. 2: Students opinion collected from a questionnaire given to 18 XA course participants (1 strongly disagree, 5 strongly agree)

#### Some 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 would have been interesting, but

anyway writing this script was a nice experience

#### Future plans

- Meeting again the Helsinki group in the spring/summer 2012 to share experiences again
- Convincing other teachers?
- Writing papers ;-)

#### References&Acknowledgments

- RAGE webpage: http://www.cs.helsinki.fi/en/rage/
- Various papers: look for Kurhila, Vihavainen and Luukkainen (some of them have been written in Finnish!)
- And more is coming?!
- In Bolzano: www.teleacademy.it (need a password)
- Collaboration for OS: F. Di Cerbo and N. El loini



#### Kiitos!! gdodero @ unibz . it

