DEPARTMENT OF INFORMATICS
UNIVERSITY OF RIJEKA

Initial Study on Students' Success in a First Programming Course

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Outline

- Introduction and motivation
- Experiment – Data Acquisition
  - Questionnaire
  - Cognitive test
- Results
- Concluding remarks

Introduction

- Programming is a standard course in any IT curriculum
  - students perception: important and challenging course
  - important prior knowledge for coursers that follow (Software Engineering)
- The goal: to find predictors for success in programming course
- Recent studies: there are no firm predictors (gender, age, high school results, motivation,...) for success in learning programming
  - related work (in UK, Danmark, Slovenia and Australia)
  - Middlesex University proposed a cognitive test (2006)

Programming course I

4 studying groups of double-major study of informatics		
	ECTS	L+ E
Mathematics (4th semester)	5	2+2
Physics (2nd semester)	5	2+2
Polytechnics (3rd semester)	5	2+2
Social sciences (1st semester)	4	2+1

- Challenge:
  - different background knowledge,
  - different motivation,
  - heterogeneous studying groups

Programming course II

- Introduction to programming:
  - programming logic, algorithm design and development,
  - basic constructs of programming in C++ (variables, constants, expressions, control structures, functions, arrays,...)
- Problems:
  - Relatively low rate of students passing the exam
  - A few excellent students (need extra projects not to be bored)

Activity	Points
Practise assignments (exrecises)	20
1st midterm exam – programming assignments	15
2nd midterm exam – programming assignments	15
1st midterm exam – theory test	10
2nd midterm exam – theory test	10
Final exam	30
	100

predicting the score

Experiment – Data Acquisition

- In the **first week** of Programming course 69 students filled in:

general background experience **questionnaire (**40 questions), Moodle

27. Koristite li neki program za rad sa zvukom (upišite koji)

28. Koristiš li neki program za rad s videom (upišite koji)

29. Koji web preglednik koristite (možete i više odgovora zaokružiti)*
- Microsoft Explorer
- Mozilla Firefox
- Opera
- Google Chrome
- Safari
- drugi
- ne koristim

30. Koje servise na internetu ste dosada koristili (može više odgovora)*
- e-pošta
- www
- FTP prijenos datoteka
- P2P (e-mule,...)
- komunikaciju (Skype, Messanger, FB chat...)
- blog
- wiki
- RSS
- drugo
- nisam

31. Jeste li već učili programirati (možete navesti više odgovora):*
- u srednjoj školi
- na fakultetu
- nisam

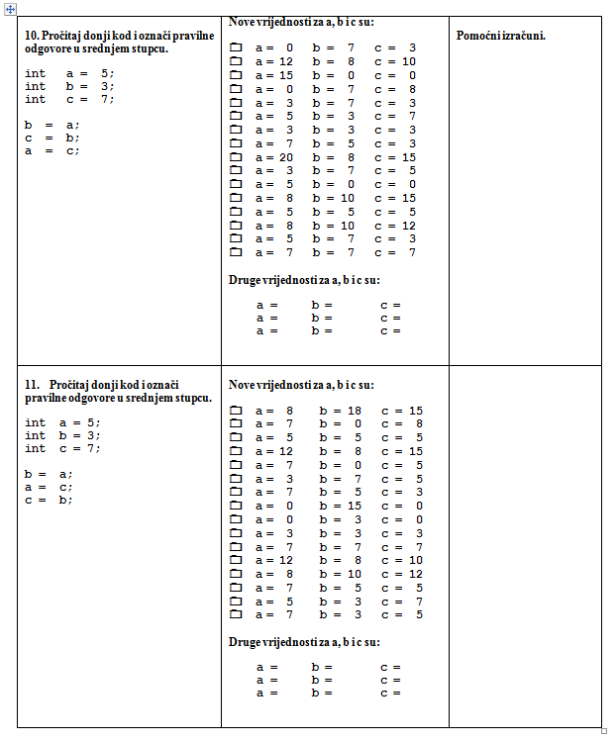
32. Ako si učio na fakultetu napiši kojem i koje predmete

33. U kojem programskom okruženju programirate (možete navesti više odgovora)
- ne programiram
- Pascal/Delphi
- Java
- C/C++
- PHP
- drugo

34. Ukoliko programiraš u drugim programskim jezicima napiši u kojima

35. Koliko je važno znanje programiranja za vaše buduće zanimanje*

cognitive test (12 questions), on paper



10. Pročitaj donji kod i označi pravilne odgovore u srednjem stupcu.
 	
`int a = 5;`
`int b = 3;`
`int c = 7;`
 	
`b = a;`
`c = b;`
`a = c;`
	Nove vrijednosti za a, b i c su:
	☐ a = 0 b = 7 c = 3
	☐ a = 12 b = 8 c = 10
	☐ a = 15 b = 0 c = 0
	☐ a = 0 b = 7 c = 8
	☐ a = 3 b = 7 c = 3
	☐ a = 5 b = 3 c = 7
	☐ a = 3 b = 3 c = 3
	☐ a = 7 b = 5 c = 3
	☐ a = 20 b = 8 c = 15
	☐ a = 3 b = 7 c = 5
	☐ a = 5 b = 0 c = 0
	☐ a = 8 b = 10 c = 15
	☐ a = 5 b = 5 c = 5
	☐ a = 8 b = 10 c = 12
	☐ a = 5 b = 7 c = 3
	☐ a = 7 b = 7 c = 7
	
	Druge vrijednosti za a, b i c su:
	a = b = c =
	a = b = c =
	a = b = c =
		Pomoćni izračuni.

11. Pročitaj donji kod i označi pravilne odgovore u srednjem stupcu.
 	
`int a = 5;`
`int b = 3;`
`int c = 7;`
 	
`b = a;`
`a = c;`
`c = b;`
	Nove vrijednosti za a, b i c su:
	☐ a = 8 b = 18 c = 15
	☐ a = 7 b = 0 c = 8
	☐ a = 5 b = 5 c = 5
	☐ a = 12 b = 8 c = 15
	☐ a = 7 b = 0 c = 5
	☐ a = 3 b = 7 c = 5
	☐ a = 7 b = 5 c = 3
	☐ a = 0 b = 15 c = 0
	☐ a = 0 b = 3 c = 0
	☐ a = 3 b = 3 c = 3
	☐ a = 7 b = 7 c = 7
	☐ a = 12 b = 8 c = 10
	☐ a = 8 b = 10 c = 12
	☐ a = 7 b = 5 c = 5
	☐ a = 5 b = 3 c = 7
	☐ a = 7 b = 3 c = 5
	
	Druge vrijednosti za a, b i c su:
	a = b = c =
	a = b = c =
	a = b = c =	

69 Students (2011/12):

Double-major Informatics with	Gender		Average age	%
	M	F		
Social sciences	4	13	20	24.5%
Polytechnics	11	6	21	24.5%
Mathematics	2	17	22	28%
Physics	6	10	21	22%
Total	23	46		

Questionnaire structure

- Demographical questions (5)
  - Gender, Age, School Region, ...
- High school score (10)
  - Mathematics, Informatics,...
- Prior IT experience (15)
  - Text processors, Interent services,...
  - Programming, programming languages
- Current bachelor and planned master group (4)
- Motivation and expectation (6)

Cognitive test

- Dehnadi-Bornat test:
  - focused on the **assignment statement**
  - define and observe the **mental models** used when thinking about assignment statements and short sequences of assignments
- 12 questions are proposed:
  - each question gives a sample Java (C++) program
    - declaring two or three variables (with initial values)
    - assignment statements
  - student has to write the new values of variables

Anticipated mental models

Model	Description	Effect
M1	right to left move	a←b ; b←0
M2	right to left copy	a←b
M3	left to right move	a→b ; 0→a
M4	left to right copy	a→b
M5	right to left move and add	a←a+b ; b←0
M6	right to left copy and add	a←a+b
M7	left to right move and add	a+b→b ; 0→a
M8	left to right copy and add	a+b→b
M9	no change	
M10	equality	a=b
M11	swap	a⇆b

Anticipated mental models of a=b

S1. [sequence] The first assignment has its effect with initial values, then the second with the values produced by the first. (One effect is reported; the corresponding box is ticked.)

S2. [simultaneous, multiple] Each assignment takes effect using the initial values of variables. (All effects are reported; the boxes corresponding to each effect are ticked.)

S3. [simultaneous, single] Each assignment takes effect using the initial values of variables, but only the effects on the destination side are reported. (One overall effect is reported; the corresponding box is ticked.)

Question	Answers/s		Model/s
5. int $a = 10$; int $b = 20$; $a = b$; $b = a$;	$a = 10$	$b = 0$	M1+S1
	$a = 20$	$b = 10$	(M1+S3)/(M2+S3)/(M3+S3)/(M4+S3)
	$a = 10$	$b = 10$	M2+S1
	$a = 0$	$b = 20$	M3+S1
	$a = 20$	$b = 20$	M4+S1
	$a = 40$	$b = 30$	M5+S1
	$a = 30$	$b = 30$	(M5+S3)/(M6+S3)/(M7+S3)/(M8+S3)
	$a = 30$	$b = 0$	M6+S1
	$a = 30$	$b = 50$	M7+S1
	$a = 0$	$b = 30$	M8+S1
	$a = 10$	$b = 20$	(M9+S1)/(M11+S1)/
			(M11+S3)
	$a = 20$ $a = 10$	$b = 20$ $b = 10$	(M10+S1)/(M2+S2)/(M4+S2)
	$a = 0$ $a = 20$	$b = 10$ $b = 0$	(M1+S2)/M3+S2)
	$a = 30$ $a = 10$	$b = 20$ $b = 30$	(M5+S2)/(M7+S2)
	$a = 0$ $a = 30$	$b = 30$ $b = 0$	(M6+S2)/(M8+S2)
	$a = 10$ $a = 10$	$b = 20$ $b = 20$	(M11+S2)

Anticipated mental models of a=b and b=a

Sample answer sheet

Levels of consitency

C0M2	consistent and correct (all answers in M2)
C0	min 8 answers in the same model (M1, M2, M3, M4, M5, M6, M7, M8, M9, M10 or M11)
C1	min 8 answers in the neighbour model (M1 and M2; M3 and M4; ...)
NOT	not consistent

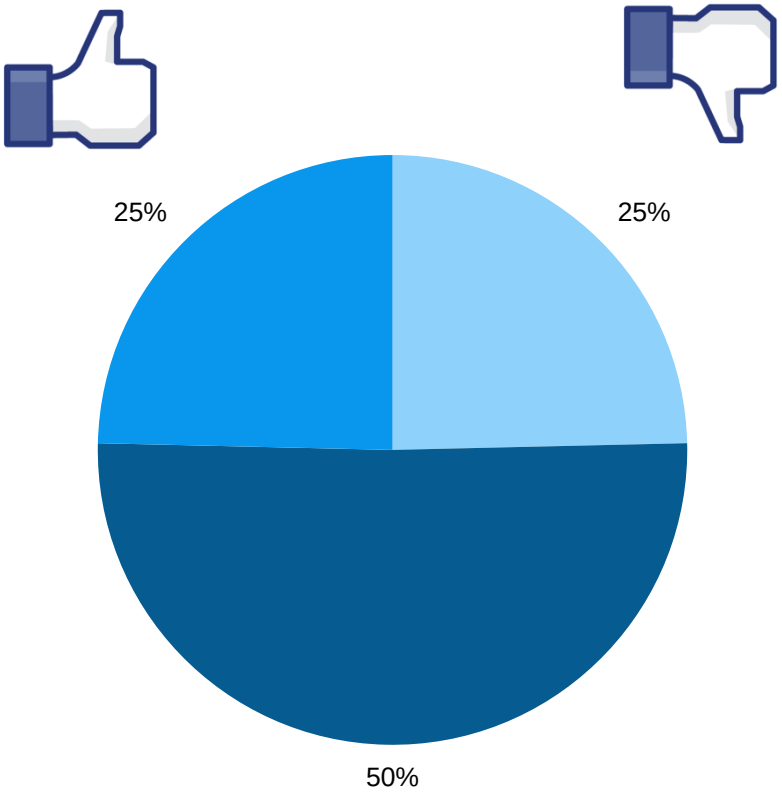
- Hypothesis: students in higher consistency level would have better score in Programming course

Questionnaire Results I

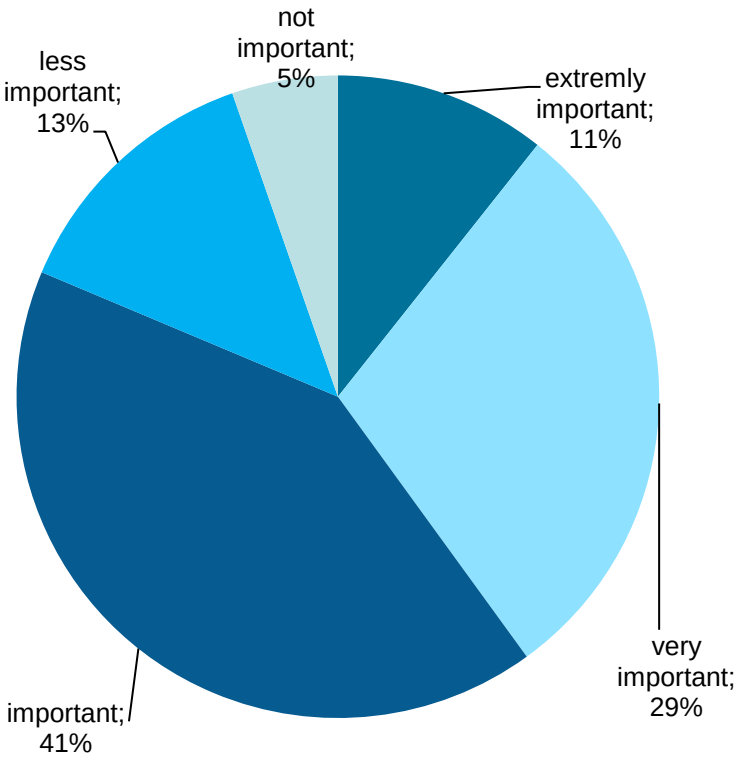
- prior programming experience
  - **YES** 46% **NO** 54%
  - prior programming languages:
    - C/C++ 33%
    - Pascal/Delphi 12%
    - Java 1%
    - PHP 0%
    - other(Logo, Ruby, ...) 5%

Questionnaire Results II

I like programming

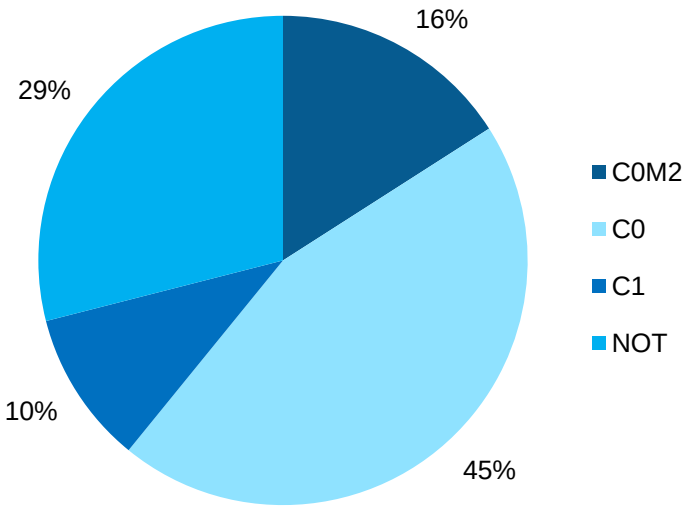


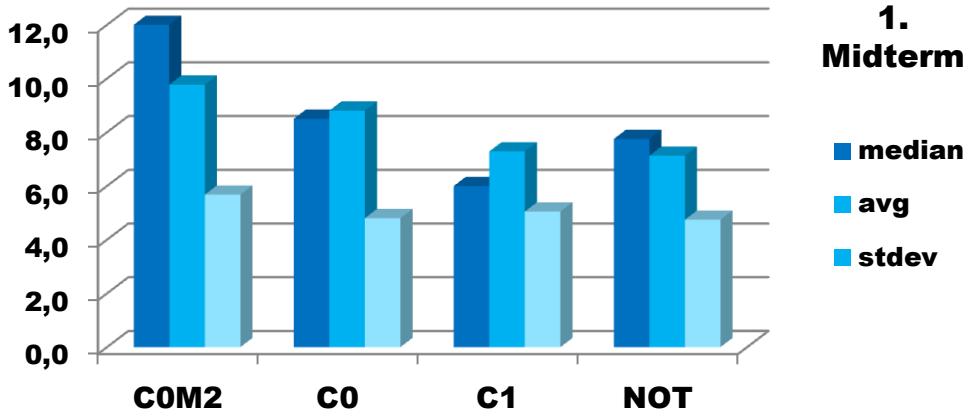
Programming importance for future job



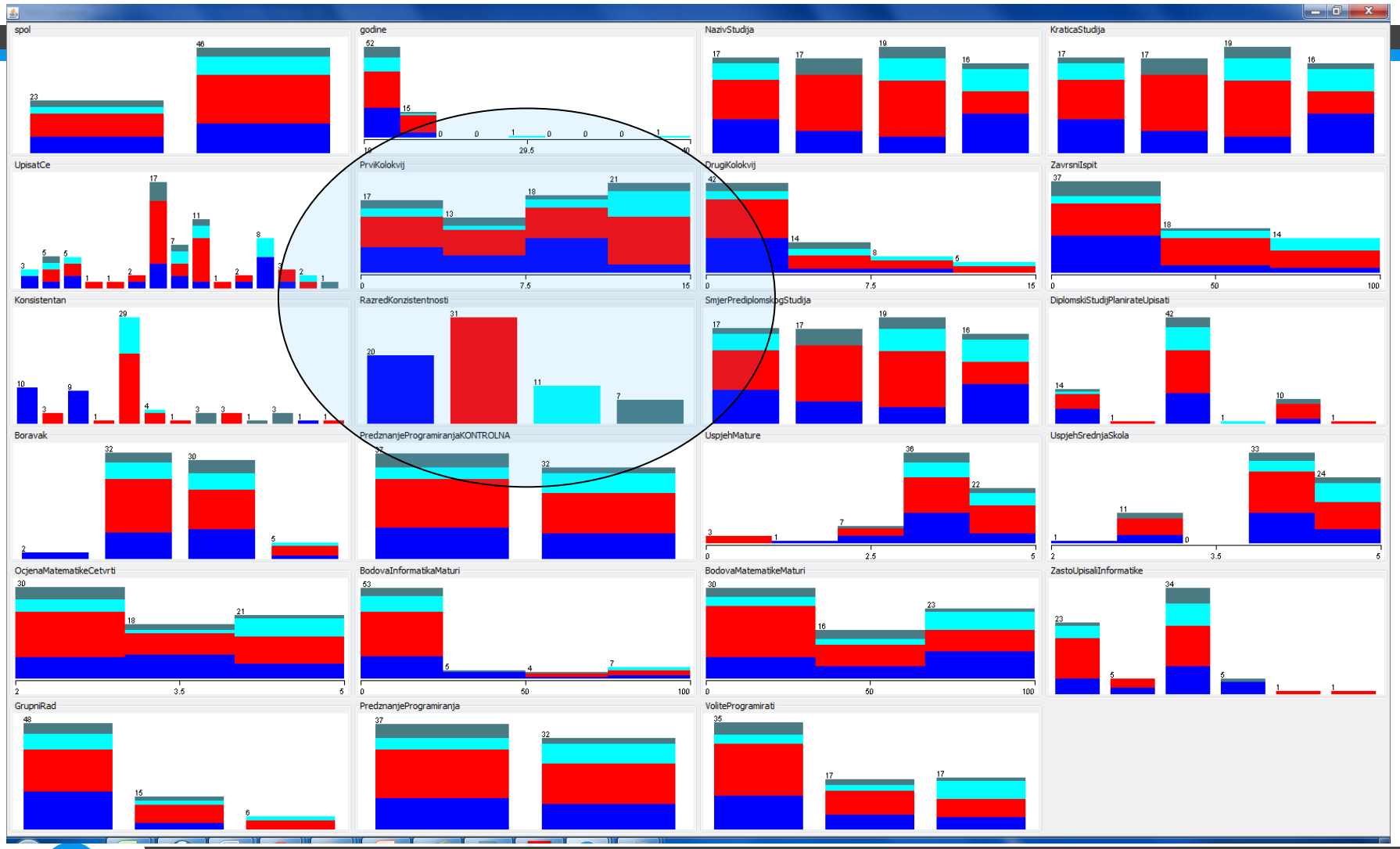
Experiment -Cognitive Test Results

– For each student the cognitive test was evaluated
– One out of original 11 cognitive models determined



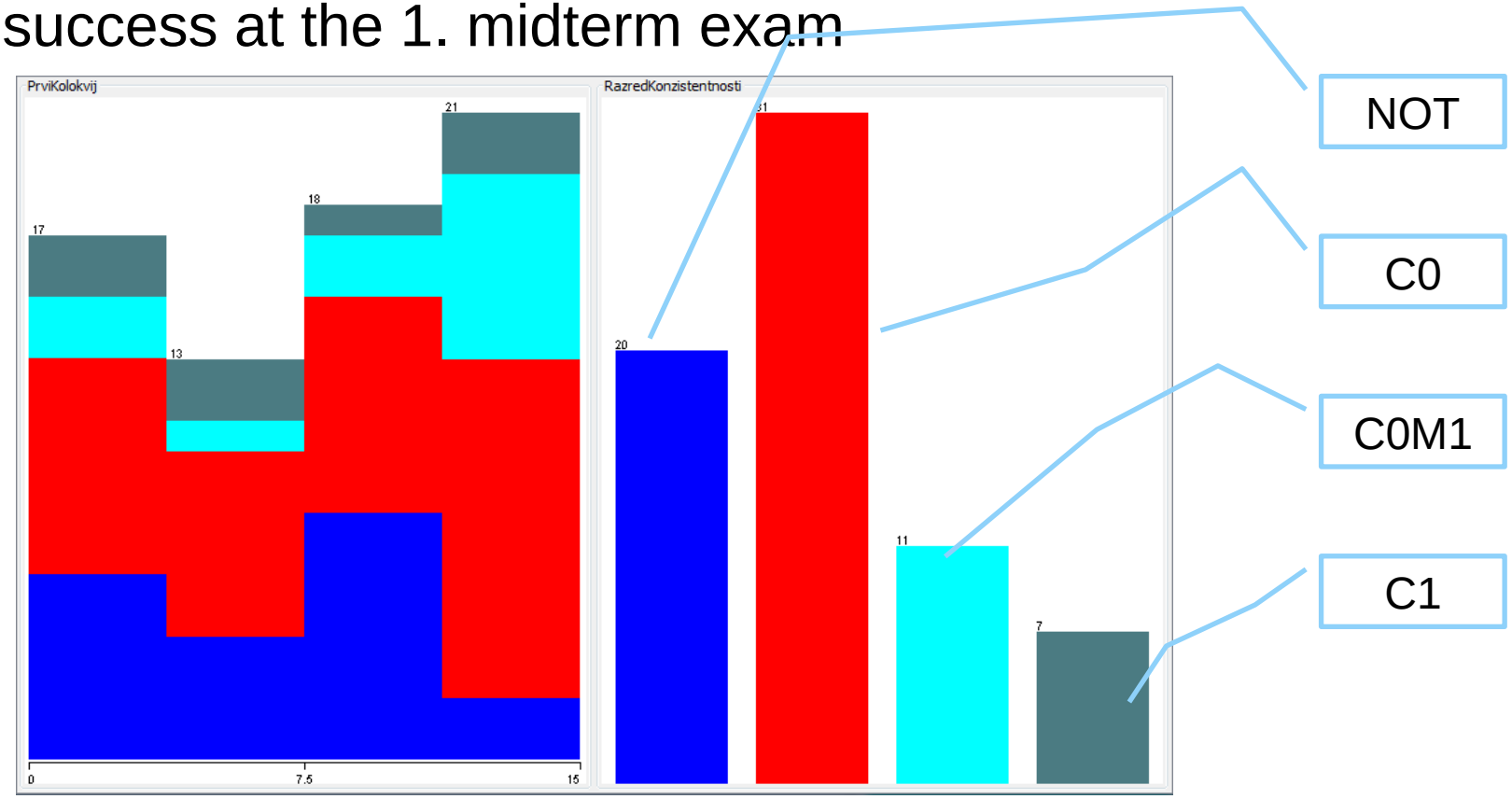


Cognitive Model Independency?



Cognitive model vs. 1. midterm

- There is no correlation between consistency levels and success at the 1. midterm exam



Interpretation

- Possible problems:
  - Final exam results are not completed yet (the last final exams will be held in September)
  - Not enough data collected (only one year)
  - Some of the students have prior programming knowledge (46 %) and some of them repeat a course (13 %)
  - A certain number of students drop out the course

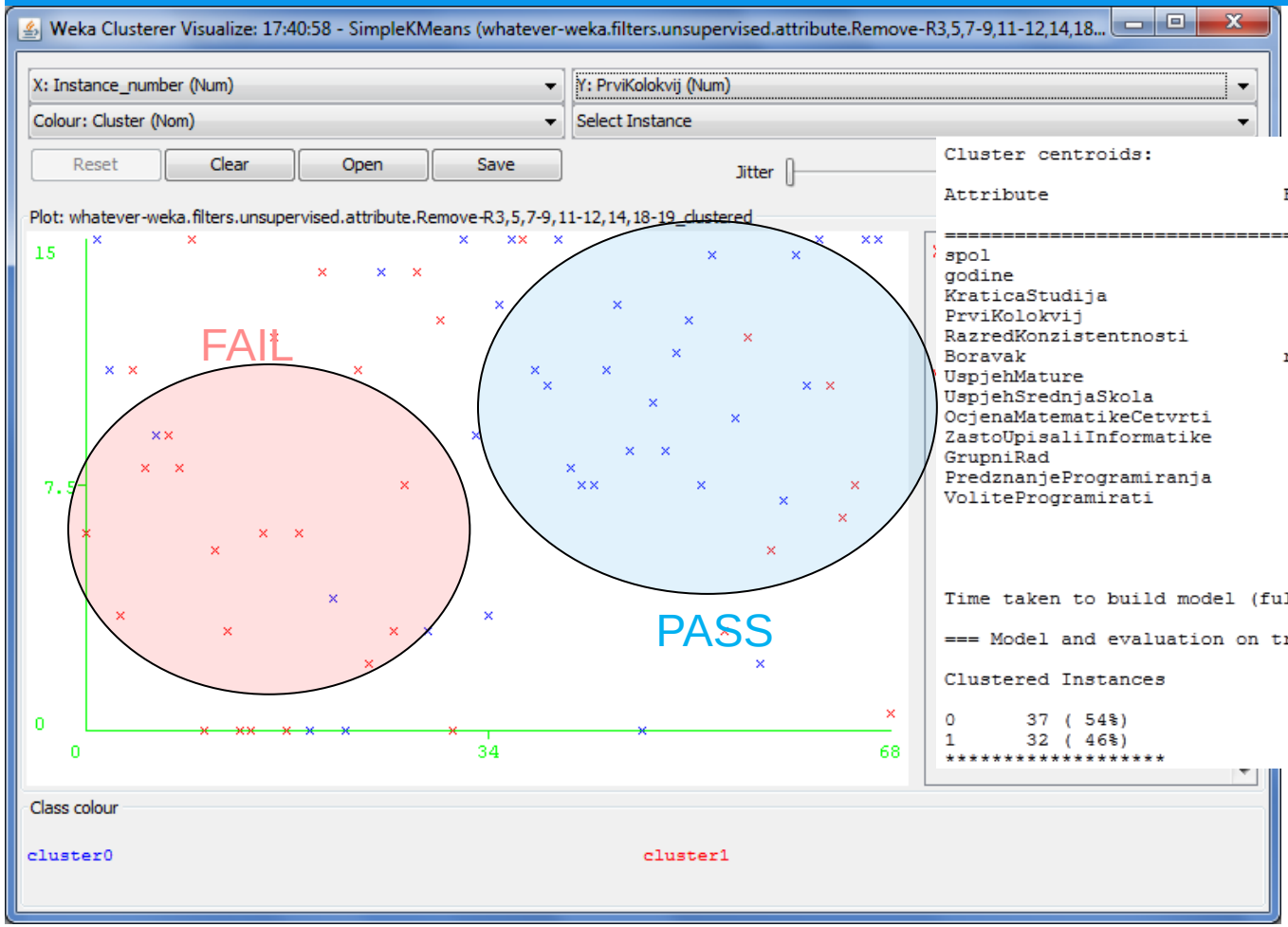
- Model evaluation using the complete final exam results

Initial DM Experiments

- collected data has a lot of quantitative values
  - data mining – WEKA experiment
    - grouping –> creating teaching groups (K-means)
    - classification tree -> predicting and gruping (C4.5)

- prediction -> exam **PASS** or **FAIL** (still waiting for the final results, Bologna)

Preliminary Clusters?



Concluding Remarks

- Purpose of presented research is to:
  - understand the reasons for students' failure
  - better understanding of background experience
  - find the most critical factors for predicting students' success
  - improve the quality of the Programming course

Future Work

- Repeat the experiment in 2012/2013.
- Build, test and verify new predictive models
- Expand test set:
  - SQ (Systemizing Quotient) test
  - EQ (Empathy Quotient) test
  - Self Rank test
  - ...

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Comments? Questions?

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Data Cleaning

- date of birth converted to years,
- 4 different answers of former knowledge agregated to YES/NO for prior programming experience,
- Geographical region normalized text
- ....

Cognitive test II

1. Read the following statements and tick the box next to the correct answer in the next column.
`int a = 10;`
`int b = 20;`
`a = b;`
	The new values of a and b are:
	☐ a = 30 b = 0
	☐ a = 30 b = 20
	☐ a = 20 b = 0
	☐ a = 20 b = 20
	☐ a = 10 b = 10
	☐ a = 10 b = 20
	☐ a = 20 b = 10
	☐ a = 0 b = 10
	☐ If none, give the correct values:
	a = b =
		Use this column for your rough notes please

sample question with **one assignment**

4. Read the following statements and tick the box next to the correct answer in the next column.
`int a = 10;`
`int b = 20;`
`a = b;`
`b = a;`
	The new values of a and b are:
	☐ a = 0 b = 20
	☐ a = 20 b = 20
	☐ a = 10 b = 0
	☐ a = 10 b = 10
	☐ a = 30 b = 50
	☐ a = 0 b = 30
	☐ a = 40 b = 30
	☐ a = 30 b = 0
	Any other values for a and b:
	a = b =
	a = b =
	a = b =
		Use this column for your rough notes please

sample question with **multiple assignments**

Anticipated mental models

- Mark sheet allowing for judgement of level of consistency

Questions	Assignment								No effect	Equal sign	Swap values	Remarks (including participants' working notes)
	Assign-to-left		Assign-to-right		Add-Assign-to-left		Add-Assign-to-right					
	Lose-value (M1) /S2 /S3	Keep-value (M2) /S2 /S3	Lose-value (M3) /S2 /S3	Keep-value (M4) /S2 /S3	Keep-value (M5) /S2 /S3	Lose-value (M6) /S2 /S3	Keep-value (M7) /S2 /S3	Lose-value (M8) /S2 /S3	Values don't change (M9) /S2	Assign means equal (M10) /S2	Swap values (M11) /S2 /S3	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
C0												
C1												
C2												
C3												

Classification tree