A Racket-Based Robot to Teach First-Year Computer Science

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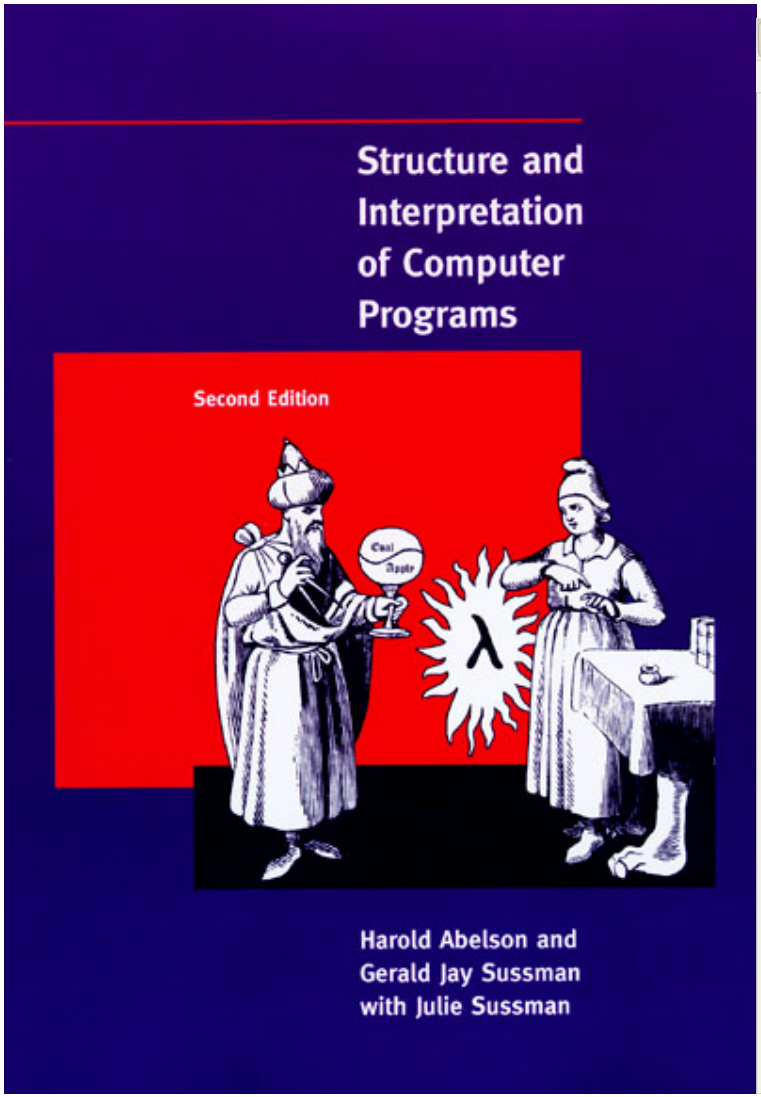
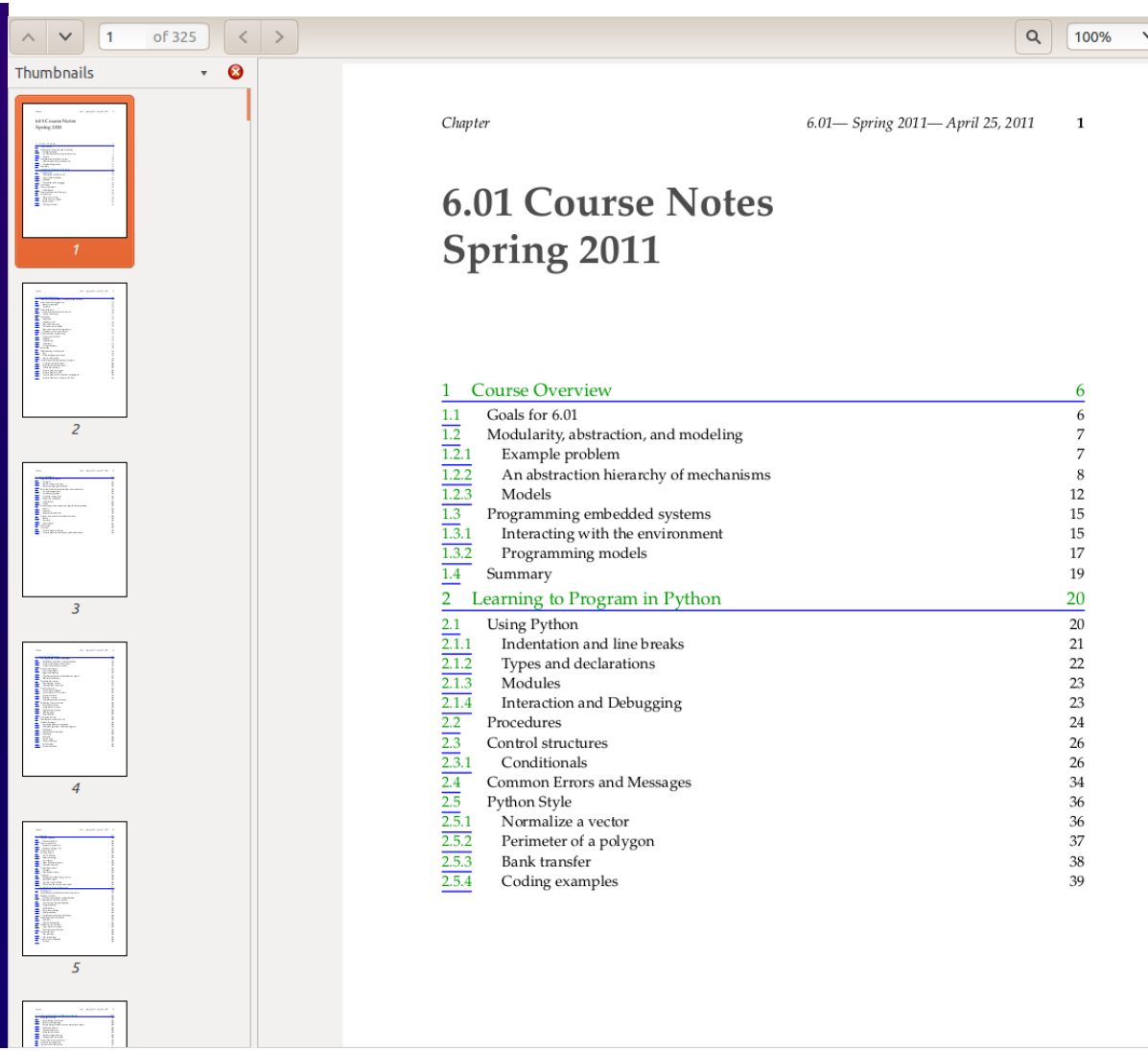
European Lisp Symposium 2014

1. The really (in)famous precedent
2. The context
3. Racket & Mirto
4. Applications
5. Assessment & Evaluation

MIT CS 6.001


Structure and
Interpretation
of Computer
Programs
Second Edition
Harold Abelson and
Gerald Jay Sussman
with Julie Sussman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MDX CSD 1000

Computer Science at Middlesex University

- New Computer Science programme for the academic year 2013/2014
- Teach students how to become autonomous learners
- *Racket*: solid mathematical background and language-independent programming skills
- *Real hardware*: Arduino, Raspberry Pi, and the Robotic Platoform *Mirto*
- Completely revised delivery and assessment methods:
  - no modules or courses
  - activities run seamlessly across the projects
  - Assessment through *Student Observable Behaviours* (SOBs).

Week structure

- **General Lecture:** introduction to topic and related project;
- **Design Workshop:** design skills in software or hardware, systems engineering (UML), HCI, security;
- **Programming Workshop:** exercises, master-classes, coaching sessions, restricted to Racket;
- **Physical Computing Workshop:** from simple logic gates to microcontrollers (Arduino) and other specialist devices controlled through Racket;
- **Synoptic Workshop:** 4 hours to investigate foundations, design, build, test and discuss projects.

Three Projects

1. traffic light system
2. dungeon game
3. Middlesex Robotic Platform

The Platform

- Base platform:
  - two HUB-ee wheels with motors and encoders (to measure actual rotation) built in
  - front and rear castors
  - two bump sensors
  - an array of six infra-red sensors
  - a rechargeable battery pack
  - an Arduino microcontroller board
- Top layer:
  - a Raspberry Pi connected to the Arduino
  - Linux with Racket (current version 5.93)
  - USB-WiFi adapter for SSH and network
  - Additional: cameras, microphones and text to speech with speakers

MIRTOlib

- Library developed by the teaching team
- Takes care of low-level serial communications

```
(send-sysex-int-msg #x7D 5 power)
```

- Students deal only with high-level Racket programs

```
(define (setMotors speed1 speed2)
  (setMotor 0 speed1)
  (setMotor 1 speed2))
```

- Students can read IR values with

```
(getIR 2)
```

Line-following with PID

```
(define proportional (- error 2000))

;; Integral component: we reset to 0 when error is 0
(cond ( (= 0 proportional) (set! intError 0))
        (else (set! intError (+ intError proportional)))
)
;; we assume dt constant, so this is just the difference
;; If derivative < 0, we moved to the left of the line
(define derivative (- proportional (- prevError 2000)))
(set! prevError error)
;; The correction is the sum of a proportional component,
;; integral component and a derivative component.
(define correction (+ (* Kp proportional)
                      (* Ki intError)
                      (* Kd derivative)) )
(cond

    ((> correction 0) ;;we are to the right
     (setMotors PWR (- PWR correction)))

    (else ;; we are to the left
    (setMotors (+ PWR correction) PWR))
)
```

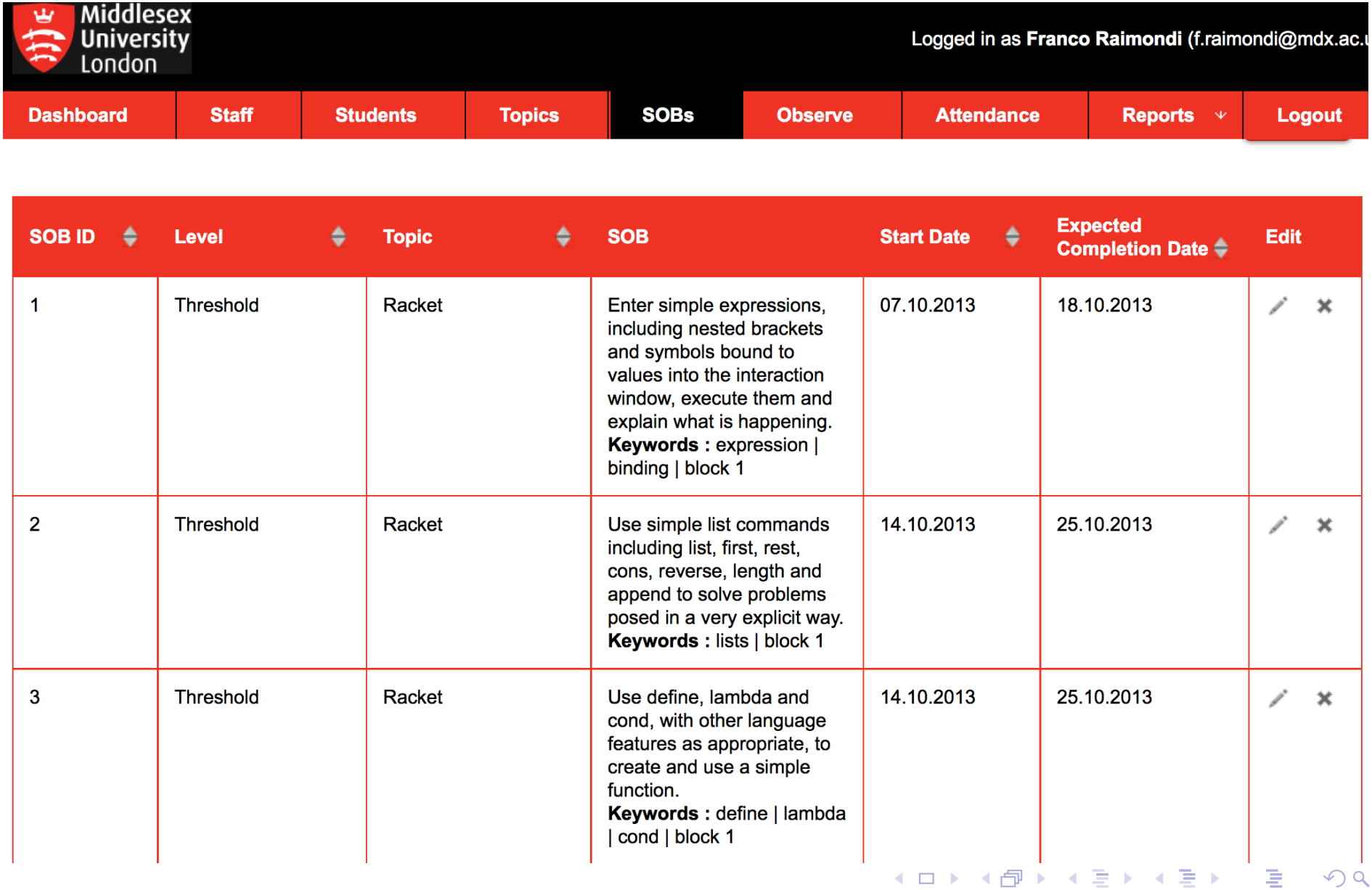
Others

- Speech-recognition: PocketSphinx connected to Racket
- Graphical Interface using X on Pi
- Web-server running on Pi
- Twitter controlled Robot

SOBs

1. **Threshold level**: essential to pass the year.
2. **Typical level**: expected for a good honours degree.
3. **Excellent level**: identifies outstanding achievements.

SOBs Tool


Middlesex University London
Logged in as Franco Raimondi (f.raimondi@mdx.ac.u
Dashboard
Staff
Students
Topics
SOBs
Observe
Attendance
Reports
Logout
SOB ID
Level
Topic
SOB
Start Date
Expected Completion Date
Edit
1
Threshold
Racket
Enter simple expressions, including nested brackets and symbols bound to values into the interaction window, execute them and explain what is happening. Keywords : expression | binding | block 1
07.10.2013
18.10.2013
2
Threshold
Racket
Use simple list commands including list, first, rest, cons, reverse, length and append to solve problems posed in a very explicit way. Keywords : lists | block 1
14.10.2013
25.10.2013
3
Threshold
Racket
Use define, lambda and cond, with other language features as appropriate, to create and use a simple function. Keywords : define | lambda | cond | block 1
14.10.2013
25.10.2013

SOBs Tool

List of Students

S.No	Student Number	First Name	Last Name	Email	Threshold
1	M00[redacted]	[redacted]	[redacted]	[redacted]@live.mdx.ac.uk	0 ✓
2	M00[redacted]	[redacted]	[redacted]	[redacted]@live.mdx.ac.uk	0 ✓
3	M00[redacted]	[redacted]	[redacted]	[redacted]@live.mdx.ac.uk	5 !
4	M00[redacted]	[redacted]	[redacted]	[redacted]@live.mdx.ac.uk	0 ✓
5	M0[redacted]	[redacted]	[redacted]	[redacted]@live.mdx.ac.uk	0 ✓
6	M00[redacted]	[redacted]	[redacted]	[redacted]@live.mdx.ac.uk	0 ✓
7	M00[redacted]	[redacted]	[redacted]	[redacted]@live.mdx.ac.uk	0 ✓

Figure : Student list with SOBs

SOBs Tool

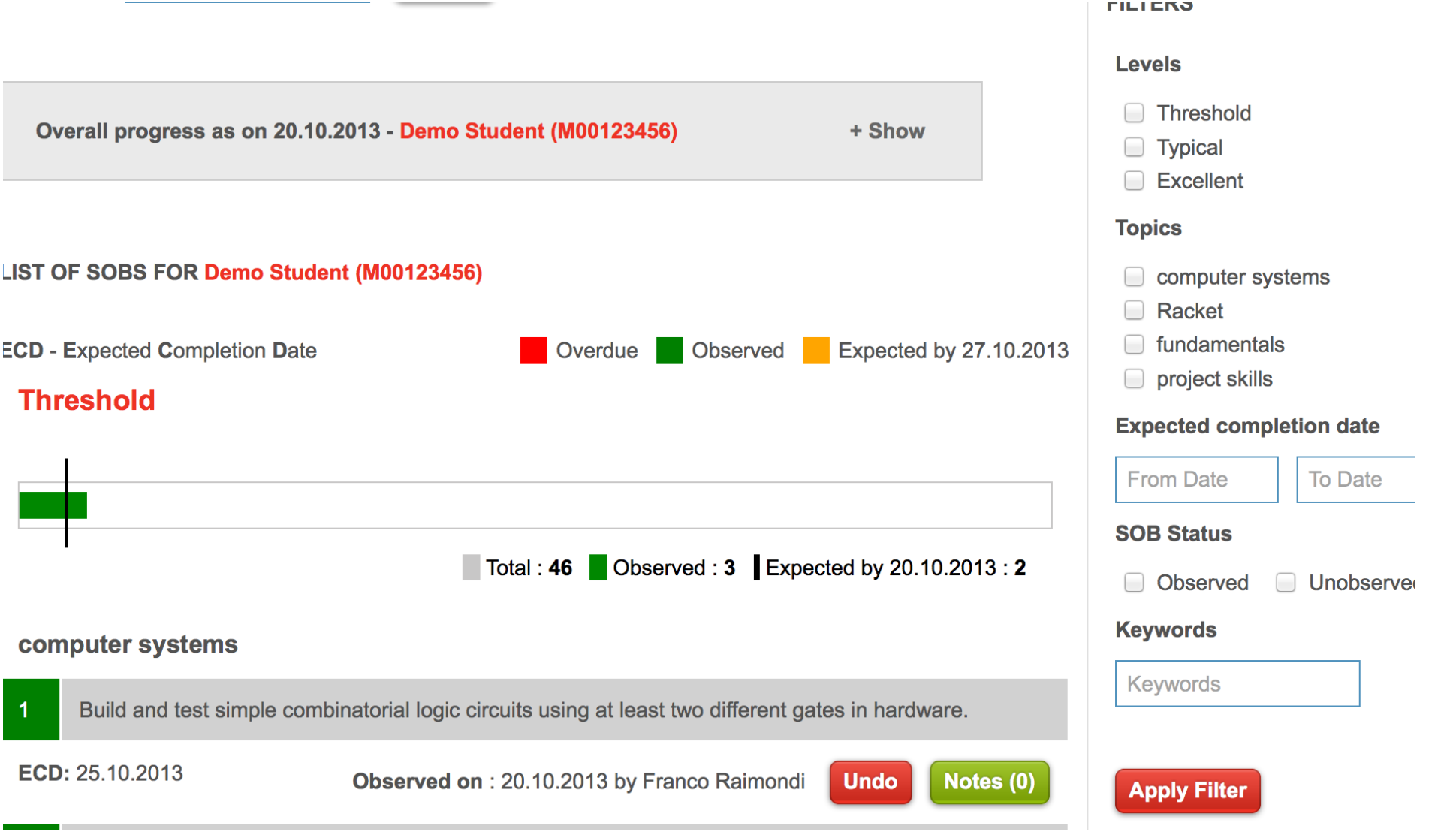


Figure : Observing a SOB for a student

SOBs Tool

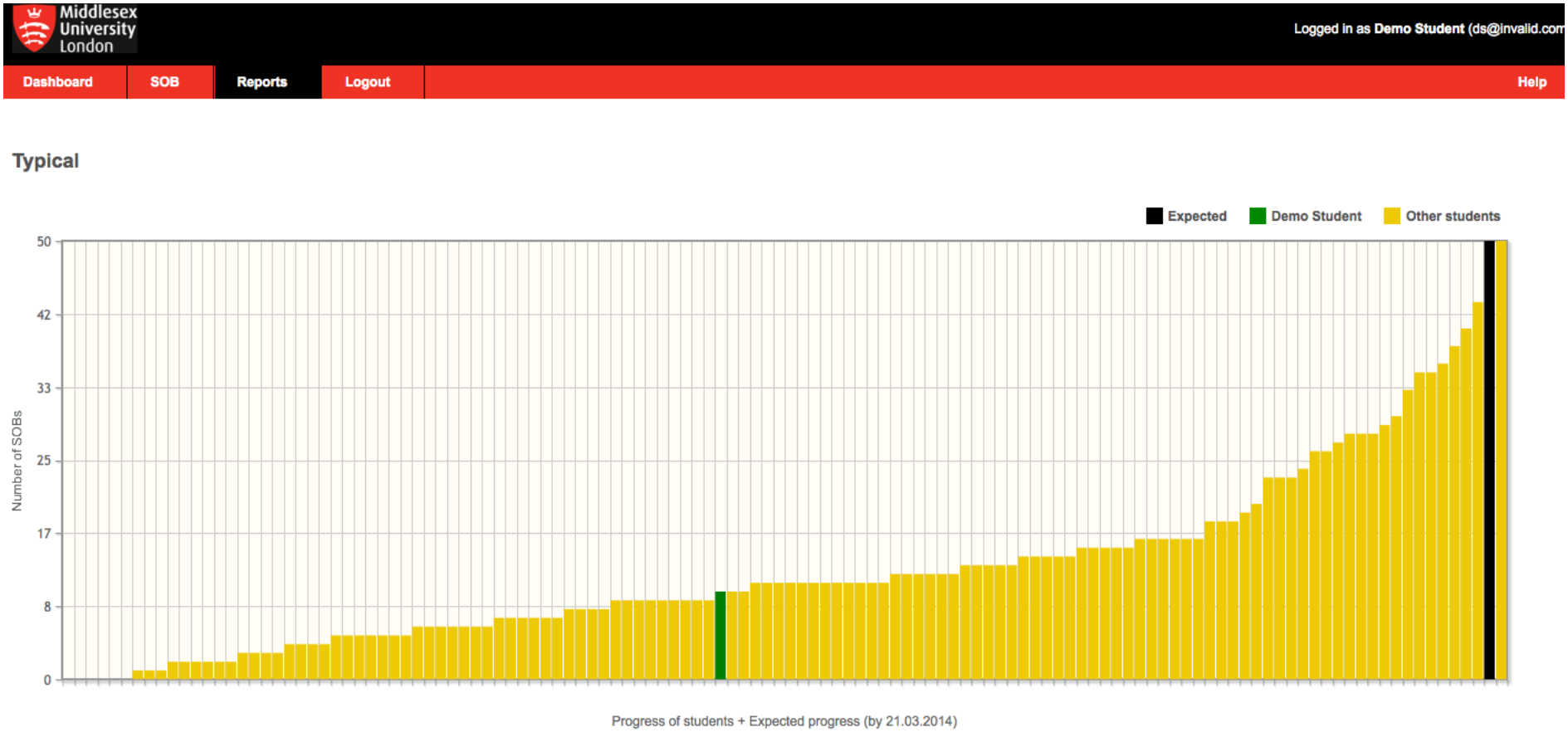


Figure : Student view: position with respect to class

Evaluation & Conclusion

- 85% success rate
- Average 90% attendance
- All students have progressed beyond threshold SOBs
- `https://github.com/fraimondi/myrtle/`
  (software and design files)