Lab on Chip Module
The team

Mathieu Odijk
Paul ter Braak
Loes Segerink
Jan Eijkel
Wouter Olthuis
Design requirements & assumptions
Mark Bentum 2014

- Request for deepening module EE
- BIOS design team composed (Jan, Mathieu, Wouter, Loes, Paul, Wesley (BKO))
- Directly the team found they preferred a multidisciplinary module with other programs participating
  - In line with BIOS expertise
- Green light for EE-BME from Mark Bentum, Ramses Wessel
- Positive reactions Ben Betlem (ST), Herbert Wormeester (AT), Katia Haijkens (BME)
  - CREATE?, TN?, ATLAS?
- Start with module design document
Design – first considerations

Starting point:
• Multidisciplinary projects
• Multidisciplinary project teams
• Formulate educational targets
• How to reach those targets? – teaching methods
• Need to know the starting knowledge of the students from the various programs
Global aims

• Get the experience of working in a *multidisciplinary* development team

• Make the full *design circle* (design, build, and measure) for a real-life measurement problem using Lab on a Chip technology

• Become acquainted with state-of-the-art prototyping techniques such as polymer casting and molding, 3D printing, photolithography and paper fluidics

• Learn the basic theory for Lab on a Chip

• Learn how to properly perform a measurement and how to interpret measurement data
Subjects

• Knowledge: fluidics, mass transport, fabrication, sensing, cell handling, signal analysis
• Skills: lab skills, design tools, prototyping, culturing, device characterization
• Project: Design, build and test your own chip
  • Multidisciplinary groups formed on first day
    • Diagnostic test + educational background
  • Groups choose their project from pitches
Intended learning outcomes

The student is able to

• List, explain and apply concepts (fluid handling, micro-organism handling, ...)
• Apply lab & fabrication skills and report the process in a lab journal
• Create a project design
• Develop a project plan, incl. schedule and task division
• Produce a report on the complete project
• Present the outcomes of the project
• Explain evaluate and discuss on the project
Hotly discussed

• How to cope with different starting knowledge of EE, AT, BME,…?

• Teaching method…: classical lecture/tutorial or PBL?
  • Students of different background can teach each other…? How..?
  • Wouter
Presently

• Successful module running with about 25 students each year

• Teaching staff + Hans van den Berg (also our PBL coach) is writing a paper for Journal of Chemical Education
Multi-/interdisciplinary aspect

2015/2016
N=28

2016/2017
N=26
Motivation for PBL
Teaching methods

as used in the Lab-on-a-Chip module

- Problem-based Learning
- Project
- Practical lab
- Diagnostic tests

What? No lectures??
What is the problem based learning?

**Problem-based learning** (PBL) is a student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem found in trigger material.

In a series of 11 problem-based learning session the students will activate their preexisting knowledge or acquire new knowledge on a range of subjects that are particularly relevant for labs on a chip.

PBL was pioneered by McMaster Universiteit in Hamilton, Ontario, Canada.

Design
Initial design ideas

• Organise module in functions categories (basically topics)
• Organise module in skills sessions
• PBL sessions of 1 day
• Project throughout the module
### Schedule Lab-on-Chip module (M10)

<table>
<thead>
<tr>
<th>Topics</th>
<th>Coordinator</th>
<th>From Lab</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
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<td>Overview</td>
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<td>Micro-organism handling</td>
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<td>Sensing</td>
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<td>Signal Analysis</td>
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<td><strong>Lab &amp; Fabrication Skills:</strong></td>
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<td>Prototyping (PDMS, paper, 3D, embossing)</td>
<td>Mathieu / Paul</td>
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<td>Culturing</td>
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<td><strong>Project: Design, build &amp; test your Chip</strong></td>
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<td>Project plan &amp; literature study</td>
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<td>Manufacturing</td>
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<td>Presenting</td>
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</table>

### Topics Coordinator 1

- Overview
- (Digital) Diagnostic test
- Fluid Handling
- Reactions
- Micro-organism handling
- Sensing
- Signal Analysis
- Lab skills
- Design tools
- Prototyping (PDMS, paper, 3D, embossing)
- Culturing
- Device characterization
- Project plan & literature study
- Design
- Manufacturing
- Testing
- Reporting
- Presenting
- Exam
### Actual timetable

#### Monday
- **14-11-2016**
  - Introduction lecture
- **21-11-2016**
  - Project kick-off
- **28-11-2016**
  - DT0: voorkennis
  - Practice PBL [all tutors and coaches]
- **5-12-2016**
  - DT0: reactions & mm1
  - DT3: microfab.
  - DT5: Sensing & mm2
- **12-12-2016**
  - DT1a: lab safety
  - Project: Device characterization?
- **19-12-2016**
  - DT1b: fluid handling
  - DT2: reactions & mm1
  - DT3: microfab.
  - DT4: culturing
  - DT5: Sensing & mm2
- **26-12-2016**
  - Project: device characterization?
- **2-1-2017**
  - Exam
  - Examen inkijkmoment
  - Repeat Exam

#### Tuesday
- **14-11-2016**
  - PBL pumping in microfluidic channel [Jan + Loes, Mathieu; Josh + Vasilis]
- **21-11-2016**
  - PBL meas. Methods 1 [extern + Loes, Jan; Anke + Hugo]
- **28-11-2016**
  - Lab skills: design tools (middag clewin etc.; ochtend comsol) [mathieu + Floris]
  - PBL cell staining [Loes + Paul, Anne; Martijn + Hugo]
  - Project: microfabrication [Mathieu + Jan, Wouter; Hai + Miguel]
  - Project: litho
- **5-12-2016**
  - PBL cell staining [Loes + Paul, Anne; Martijn + Hugo]
  - PBL optical sensing [Wouter + Mathieu, Jan; Anke + Jasper]
- **12-12-2016**
  - Project: litho
- **19-12-2016**
  - Project: litho
- **26-12-2016**
  - Project: litho

#### Wednesday
- **14-11-2016**
  - PBL mixing for cell culture [Jan + Mathieu, Wouter, Josh + Vasilis]
  - PBL meas-transp.1; protein detection [Jan + Wouter, Loes; Hai + Miguel]
- **21-11-2016**
  - Lab skills: design tools (middag clewin etc.; ochtend comsol) [mathieu + Floris]
  - PBL cell staining [Loes + Paul, Anne; Martijn + Hugo]
- **28-11-2016**
  - Project: microfabrication [Mathieu + Jan, Wouter; Hai + Miguel]
  - Project: Device characterization?
- **5-12-2016**
  - Project: litho
- **12-12-2016**
  - Project: Device characterization?
- **19-12-2016**
  - Project: Device characterization?
- **26-12-2016**
  - Project: Device characterization?
Time division
Problem-based Learning (PBL)

what and why?

- The basic knowledge is offered via PBL.
- Complex, multi-faceted, and realistic problems.
- Develop knowledge, problem solving skills, self-directed learning, collaboration skills, and to motivate.
- The teacher is "facilitator of learning", coach.
- Like professionals learn on the job, students are supposed to learn while doing PBL.

- The whole point is **not to solve** the problem, but to use it to learn.

In this module, students will tackle 11 problems in total:
Problem-based Learning (PBL)

*an overview of the problems*

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>0.</td>
<td>Practice: Why miniaturizing lab functions on a chip?</td>
</tr>
<tr>
<td>1.</td>
<td>Fluid transport 1 Liquid transport</td>
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<tr>
<td>2.</td>
<td>Fluid transport 2 Mixer/cell culture chip</td>
</tr>
<tr>
<td>3.</td>
<td>Measurement methods – 1</td>
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<tr>
<td>4.</td>
<td>Mass transport 1 Protein sensing</td>
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<td>5.</td>
<td>Mass transport 2 Channel with sensor</td>
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<td>6.</td>
<td>Microfabrication</td>
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<td>7.</td>
<td>Micro-organism handling – 1</td>
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<td>8.</td>
<td>Micro-organism handling – 2</td>
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<td>9.</td>
<td>Electrochemical sensing - River water</td>
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<td>10.</td>
<td>Optical sensing - Tea party</td>
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<td>11.</td>
<td>Measurement methods – 2</td>
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</tbody>
</table>

Each problem takes one whole day:
### Scheduled PBL time

#### Example: week 1 of the module

#### Weekly roster

<table>
<thead>
<tr>
<th>Module 10 Lab on a Chip – week 1</th>
<th>Monday 14/11</th>
<th>Tuesday 15/11</th>
<th>Wednesday 16/11</th>
<th>Thursday 17/11</th>
<th>Friday 18/11</th>
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<tbody>
<tr>
<td>1e</td>
<td>8:45-9:30</td>
<td><strong>Introduction lecture</strong></td>
<td><strong>PBL pumping</strong></td>
<td><strong>PBL mixing for cell cult.</strong></td>
<td>Kick-off lab skills</td>
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<td></td>
<td></td>
<td>CR 2N</td>
<td>RA2234 ( &amp; RA2337)</td>
<td>RA2231 ( &amp; RA2237)</td>
<td>CR 2N</td>
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<td></td>
<td></td>
<td>Jan en Albert</td>
<td>Josh + Vasillis</td>
<td>Josh + Vasillis</td>
<td>Paul</td>
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<tr>
<td>2e</td>
<td>9:45-10:30</td>
<td><strong>DT0 start test</strong></td>
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<td>DT1a lab safety</td>
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<td>Paul</td>
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<td>3e</td>
<td>10:45-11:30</td>
<td><strong>Kick off PBL + Project</strong></td>
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<td>EXP1 Dilution series</td>
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<td>CR 3B</td>
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<td>CR 4028</td>
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<td>Wouter, Mathieu, Jan Paul</td>
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<td>Project meeting</td>
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<td>4e</td>
<td>11:45-12:30</td>
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<td>Lunch</td>
<td>Lunch teachers and SAs CR2510</td>
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<td>5e</td>
<td>lunch</td>
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<tr>
<td>6e</td>
<td>13:45-14:30</td>
<td><strong>PBL exercise</strong></td>
<td><strong>PBL pumping</strong></td>
<td><strong>PBL mixing for cell cult.</strong></td>
<td>EXP1 Dilution series</td>
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<td></td>
<td></td>
<td>RA2334: Jan, Loes, Josh, Vasillis, Anke, Hugo</td>
<td>RA2234 ( &amp; RA2337)</td>
<td>RA2231 ( &amp; RA2237)</td>
<td>CR 4028</td>
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<td>Josh + Vasillis</td>
<td>Josh + Vasillis</td>
<td>Paul + Martijn</td>
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<td>Backup: Mathieu</td>
<td>Backup: Mathieu</td>
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<td>7e</td>
<td>14:45-15:30</td>
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<td>RA2335: Wouter, Paul, Mathieu, Miguel, Hai, Martijn</td>
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<tr>
<td>8e</td>
<td>15:45-16:30</td>
<td><strong>PBL pumping</strong></td>
<td><strong>PBL mixing for cell cult.</strong></td>
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<td>RA2237: Josh + Jan RA2334: Vasillis + Loes</td>
<td>RA2231: Josh + Mathieu RA2237: Vasillis + Jan</td>
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<td>Backup: Mathieu</td>
<td>Backup: Wouter</td>
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<td>9e</td>
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</table>
Problem-based Learning (PBL)
overview of the one PBL-day

<table>
<thead>
<tr>
<th>time</th>
<th>function</th>
<th>details</th>
<th>remarks</th>
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</thead>
<tbody>
<tr>
<td>08:45 - 08:55</td>
<td>Kick-off</td>
<td>• get the students in class</td>
<td>by one of us</td>
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<td>08:55 – 10:30</td>
<td>Action Plan</td>
<td>• Analyze the problem</td>
<td>working unsupervised</td>
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<td>• Define an action plan</td>
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<td>10:45 – 12:30</td>
<td>Execution of work</td>
<td>• Studying literature</td>
<td>working under the guidance of SA’s</td>
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<td></td>
<td></td>
<td>• Solving the problem</td>
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<tr>
<td>13:45 – 15:30</td>
<td>Execution of work</td>
<td>• Solving the problem</td>
<td>working unsupervised</td>
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<td></td>
<td></td>
<td>• Preparation of presentation</td>
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<tr>
<td>15:45 – 17:30</td>
<td>Presentation and discussion</td>
<td>• 3 teams per class</td>
<td>PBL coach (one of us) and SA are present</td>
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<td>• 4 students in each team</td>
<td>Confirmation for the good teams (steep)</td>
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<td>• Cruel fate selects the presenter</td>
<td>learning for the mediocre teams</td>
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</tbody>
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There is a predefined strategy:
Problem-based Learning: 
*following a predefined strategy*

For every PBL session, you will work on a **big, ill-defined** problem, following a predefined **strategy**:

1) What is the problem? Formulate in your own words;
2) What do we want to present?
3) What do we already know?
4) What are the new concepts?
5) What should we study?
6) Working plan, containing all tasks to be performed;
7) Division of work

*From: ‘De Zevensprong’, Universiteit Maastricht*
Problem-based Learning: 

some additional facts

• PBL in a **team** of four students.

• We choose the fellow students in a team based on multidisciplinarity.

• The teacher coaches a **group** consisting of **three** teams during the PBL presentation session.

• For each PBL, the results of the team are presented (the presenter is selected randomly (**cruel fate**) from the team members) to the other students in the session (**8th** and **9th** hour).

• Tutors are available at scheduled times (**3rd** and **4th** hour) to give assistance in solving PBL problems.

• 1 full day to work on each problem.

• PBL work is graded every session, based on the presentation. The grade is an indication of the team’s progress, and contributes for a small % (5%) to the final grade of the module.
Skills sessions design

• Work in smaller groups in the lab
• Focus on practical work
• Aim is real hands-on experience
## Skills sessions by topic

<table>
<thead>
<tr>
<th>Content</th>
<th>Practical implementation</th>
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<tbody>
<tr>
<td>1: basic lab skills &amp; safety</td>
<td>Make and measure a dilution series</td>
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<tr>
<td>2a: Design tools &amp; software</td>
<td>Design your own mixer</td>
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<tr>
<td>2b: Rapid prototyping</td>
<td>Fabricate lab on chips, using PDMS, 3D printing, SU8, Micromilling</td>
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<tr>
<td>3a: Cell seeding &amp; culturing</td>
<td>Culture HUVEC cells in a PDMS chip</td>
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<tr>
<td>3b: Cell staining</td>
<td>Fluorescent staining of the HUVECs in the chip</td>
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<tr>
<td>4: Characterization</td>
<td>Use SEM, AFM, Microscope to do device characterization</td>
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</tbody>
</table>

Deliverable is typically a lab journal (or process flow document)
Project organisation

• Teams consist of 4 to 5 students
• We make the teams, based on background, score on the entry-level diagnostic test, ability to properly use Osiris, etc..
• We pitch our projects, teams choose a topic in order of preference
• We decide which team is going to do which project

• Each team gets a daily supervisor (PhD student), and a process supervisor
• Weekly meetings with process supervisor
• Deliverables are:
  • project plan & an individual project plan pitch
  • design and process flow
  • final report & presentation
Projects

Project 1
• Glucose

Project 2
• Microbrewery

Project 3
• Xanthine

Project 4
• Artificial Seeds

Project 5
• Endoparasite home test
Full design circle

- Literature study & list of requirements
- Initial design
- Fabricated sensor
- Measurements
- Report & presentation

Design circle
Synergy in learning formats

cell staining
PBL

thrombosis
on chip | project

cell culture
lab skills
Power of repetition

• Example Péclet PBL, mixer assignment and testing, as well as project.
Examples & experiences
Problem-based Learning:

*one example*

River water – electrochemical sensing

*Learning aims:*
- understanding electrochemical detection methods: potentiometry, conductometry and amperometry;
- choosing the preferred method for a given situation.

*Problem statement*
Recently, I overheard this coffee-break discussion (obviously you (and me) want to know the answer to every question asked):

Josh: “Interesting, all these available electrochemical sensors.”
Carol: “Huh? oh, yea, right. Which operational principles are there anyway?”
Josh: “You tell me. Would be great to test river water quality.”
Carol: “Hmm, ok, Mr. Environmentalist, which kind of sensor would you choose then?”
Josh: “Depends on whether the river flows or not.”
Carol: “Ah, yes, rivers tend to flow, true... One principle down, two to go, right?”
Josh: “Not entirely, dear Carol, that depends on whether you want to know specifically what ions are in the river, or just whether the river water is like fresh water or salty.”

(... another half page of text)

*Literature:*
Hand-out ‘Measurements of chemical quantities (Olthuis)’; (on BlackBoard)
Excerpt of the thesis of M.J.J. van Megen, section 2.1 and 2.2. (on BlackBoard)

PBL versus lectures

*some observations*

**PBL**

+ active learning
+ student involvement required and (almost) guaranteed
+ creative thinking required
+ (better) prepared for real-life problems
+ soft skills built-in

- student complains (‘hard work, no complete answers, we want lectures, what do we need to learn?’)
- PBL coaching is hard, requires several (new) skills, can be confronting (*but very rewarding too*)
- PBL doesn’t scale economically with student numbers
- repetitively practicing skills is hardly possible; roof-tiling learning aims helps

**Lectures**

+ can be motivating, enjoyable
+ easy to cover all learning aims (by the teacher(!))
+ are cheap

- all +’s at PBL with an extra negation
PBL

some additional observations

Writing proper PBL problems is an art:
• ill-defined and open, but no riddles
• not too long (and not too short)
• all the learning aims should be targeted

Good, appropriate reading material is essential (also for exam preparation)

Teachers and SA’s must be trained (especially in the art of coaching, observing and asking guiding questions)
Skills example: design session

- Goal: design your own mixer that can be fabricated by rapid prototyping
Skills example: Rapid prototyping

Mixer

Non-Mixer

Pictures from: Josh Loessbergh-Zahl and Vasillis Papadimitriou
Project example: Organs-on-chips
Deep vein thrombosis

- Clots in the large veins
- 1 in 1000 persons per year
- Mostly in elderly
  - Cost for society in billions and rising
  - Risk of life-threatening pulmonary thrombo-embolism

- Clots form near venous valves
- Virchow’s triad of clotting
  - Blood flow pattern
  - Vessel wall
  - Blood clotting factors
Project example: Organs-on-chips
Deep vein thrombosis

- Living, microfluidic laboratory models of human organs and diseases
- Mimic complex diseases
- Can we realistically mimic deep vein thrombosis in a microfluidic chip?
Assessment
# Intended learning outcomes

The student is able to

<table>
<thead>
<tr>
<th>Intended learning outcomes</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>List, explain and apply concepts categorized into six functions: fluid handling, mass</td>
<td>Problem-based learning assignments</td>
</tr>
<tr>
<td>transport and reactions, micro-organism handling, sensing, measurement methods and</td>
<td></td>
</tr>
<tr>
<td>microfabrication</td>
<td></td>
</tr>
<tr>
<td>Apply lab &amp; fabrication skills (lab skills, prototyping and culturing) and report the</td>
<td>Lab and fabrications skills</td>
</tr>
<tr>
<td>process in a lab journal</td>
<td></td>
</tr>
<tr>
<td>Create a project design with a process flow for lab on a chip device.</td>
<td>Design tools and project design</td>
</tr>
<tr>
<td>Develop a project plan: formulate a hypothesis, list of project goals and device</td>
<td>Project plan</td>
</tr>
<tr>
<td>specifications. Plan the project schedule and task division.</td>
<td></td>
</tr>
<tr>
<td>Produce a report with analysis, evaluation, discussion and conclusion on the complete</td>
<td>Project report</td>
</tr>
<tr>
<td>project.</td>
<td></td>
</tr>
<tr>
<td>Present the outcomes of the project.</td>
<td>Project presentation</td>
</tr>
<tr>
<td>Explain evaluate and discuss on the project.</td>
<td>Final exam</td>
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</table>
# Assessment plan

<table>
<thead>
<tr>
<th>Test</th>
<th>Assessment method</th>
<th>% of total score</th>
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<tbody>
<tr>
<td>Diagnostic test</td>
<td>dT0-dT6 Multiple choice questions, digital</td>
<td>0%</td>
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<tr>
<td>PBL exercises</td>
<td>P1-P11 Presentation</td>
<td>5%</td>
</tr>
<tr>
<td>Lab and fabrication skills</td>
<td>e1-e3, p.f. Lab journal, written digital</td>
<td>5%</td>
</tr>
<tr>
<td>Project plan</td>
<td>D1a Project plan document, written digital</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>D1b Project plan presentation, oral</td>
<td>5%</td>
</tr>
<tr>
<td>Project design</td>
<td>D2 Project design document (with process flow), written digital</td>
<td>5%</td>
</tr>
<tr>
<td>Project report</td>
<td>D3 Project report, written digital</td>
<td>20%</td>
</tr>
<tr>
<td>Project presentation</td>
<td>D4 Final project presentation, oral</td>
<td>10%</td>
</tr>
<tr>
<td>Final exam</td>
<td>T1 Open and multiple choice questions, written</td>
<td>40%</td>
</tr>
</tbody>
</table>

* minimum mark 5.5 (on a scale from 1.0-10.0)
PBL | 5%

- Presentation
  - Directly at end PBL
  - One presenter randomly chosen

- Diagnostic test
  - Individually
  - End of the week | Socrative

- Form
  - 1 teacher and student assistant
Project | 50%

- Project plan
  - Individual presentation (5%) and document (10%)
- Design (5%)
- Report (20%)
- Group presentation (10%)
# Marks

<table>
<thead>
<tr>
<th>Educational format</th>
<th>n</th>
<th>average</th>
<th>Standard deviation</th>
<th># &lt; 5.5</th>
<th>max</th>
<th>min</th>
<th># elements</th>
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<tbody>
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<td>28</td>
<td>7.3</td>
<td>0.18</td>
<td>0</td>
<td>7.7</td>
<td>7.0</td>
<td>11</td>
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<tr>
<td>Lab skills</td>
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<td>7.3</td>
<td>0.33</td>
<td>0</td>
<td>7.9</td>
<td>6.8</td>
<td>4</td>
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<td>0</td>
<td>8.3</td>
<td>6.6</td>
<td>5</td>
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<td>6.5</td>
<td>1.1</td>
<td>5</td>
<td>8.5</td>
<td>4.1</td>
<td>1</td>
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<tr>
<td>Re-exam</td>
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<td>6.5</td>
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<td>0</td>
<td>7.2</td>
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<td>1</td>
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<tr>
<td>Final Mark</td>
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<td>7.1</td>
<td>0.51</td>
<td>0</td>
<td>8.1</td>
<td>6.2</td>
<td>-</td>
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<td>8.2</td>
<td>7.2</td>
<td>11</td>
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<tr>
<td>Lab skills</td>
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<td>0.69</td>
<td>0</td>
<td>9.0</td>
<td>5.8</td>
<td>4</td>
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<tr>
<td>Project</td>
<td>26</td>
<td>7.4</td>
<td>1.11</td>
<td>1</td>
<td>8.0</td>
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<td>Exam</td>
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<tr>
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<td>0.52</td>
<td>0</td>
<td>7.6</td>
<td>6.2</td>
<td>1</td>
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<tr>
<td>Final Mark</td>
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<td>7.5</td>
<td>0.36</td>
<td>1</td>
<td>8.1</td>
<td>1.7</td>
<td>-</td>
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Marks

![Bar chart showing marks for different categories: PBL, Lab skills, Project, Exam, Re-exam, Final Mark. The chart compares the marks for 2015/2016 and 2016/2017.](image)
Evaluations
Evaluation

• Feedback during module
  • Students
  • Teaching team

• Feedback after module
  • Students SEQ evaluation
  • Teaching team
Feedback students

• Contact hours
• Get to know the students
• Open for questions/suggestions
• Adjust if possible

• Example is that students were confused in which group they are placed.
  • Solution: table send via blackboard
Feedback teaching team

• Once a week sit together
• Discuss how it is going
  • PBL
  • Skills practical
  • Project
• Adjust if possible
Example of the minutes from 24-11-2016

• Lab skills:
  • -(Martijn) Last week’s lab skills went quite well, but most of the groups were unprepared which cost them some time in reading the manual on the spot, which results on not finishing on time. Grading of the lab journals will be done the coming week.

• Action points for next week:
  (Tutors) Lab skills tutors can find the schedule on the draaiboek and info about their job on the Lab skills manual (both can be found on BB). For further questions ask Paul.

• Project:
  • -For all groups the project is in very early stage but everything seems on track.
  •

• Action Points:
  • (Jan) The students should be informed about a peer-review grading of the project.
Examples

• **PBL:**
  - PBLs are improved compared to last year
  - The students were slightly confused about the general goal of PBL 3 - Measurement methods. This may have come from the different nature of the reading material (i.e. absence of a chapter in the tutorial about this PBL).

• Action points:
  - (all) A tutorial document for the whole course should be made.
  - (all) Unexperienced tutors should not be in the same PBL (for next year).
  - (all) The training course for PBL should be followed for new tutors (for next year).
  - (all) The grading criteria for the PBLs should be known to all, and all the filled assessment forms should be placed in the “box” mentioned by Mathieu.
  - (all) In case that a learning aim is not met by any team, a small “lecture” should be given after the presentations to clear up any misconceptions.
  - (all) The student names of each team should be written in the assessment forms because students have changed PBL teams and we need to keep track of these changes. The groups on blackboard should be updated with these changes.
  - (Paul) Paul should be aware of the student changes mentioned above so he gives the correct grade to the students in the excel file.
SEQ Evaluation

Overall indicators

Learning (Scale width: 5)
Project (Scale width: 5)
Assessment (Scale width: 5)
Effort to put into study (Scale width: 5)
Appreciation (Scale width: 5)
Appreciation (scale width: 10)

2015-2016
7.8

2016-2017
7.2

0.8
2.2
SEQ Evaluation

SEQ results 2015-2016

As a whole, I learned a lot in the module

The module was logically put together. Consider for instance: parts of the module were connected well; good sequence of module parts

The module was well organised. Consider for instance: clear assignments, clear rules for assessments

SEQ results 2016-2017

As a whole, I learned a lot in the module

The module was logically put together. Consider for instance: parts of the module were connected well; good sequence of module parts

The module was well organised. Consider for instance: clear assignments, clear rules for assessments
Improvements 2015-2016

PBL

• Adjust 1st four PBLs
  • Especially length and information sources
• Change the order of given PBLs
  • Put “boring” PBLs together with “cool” PBLs
• Everyone should check their learning objectives
  • Adjust them and make them S.M.A.R.T
  • Add objectives to all PBLs
• Learning objectives should match with exam-questions
Improvements 2015-2016

Skills
- Adding assessment criteria
- Implementing spectrophotometry in skills practical
- Let students prepare practical in advance
  - Saves time
- More time for example cells practical
  - Students are slow, since they are new into the topic
Improvements 2015-2016

Project
• Add a weekly meeting with supervisor

• Arrange the SA ‘s on time and instruct them
  • Communication,
  • Reservation of setup
  • Ordering materials
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- Still too long
- Reader made!
- Students “stayed”
- Better fit
- Students know what to learn
Module 10 LOC 2017-2018

Skills
• Adding assessment criteria
• Implementing spectrophotometry in skills practical
• Let students prepare practical in advance
  • Saves time
• More time for example cells practical
  • Students are slow, since they are new into the topic

Writing a labjournal is a criteria
Is done and will replace a part of the general skills
Saved time, however should be handed in before the practical
Students are finished on time

Students are finished on time
Module 10 LOC 2017-2018

Project

• Add a weekly meeting with supervisor

• Arrange the SA’s on time and instruct them
  • Communication,
  • Reservation of setup
  • Ordering materials

Students are kept on track. Supervisors are more involved

Less chaos for the SA’s

Went a little better however still room for improvement
Questions...?
Questions?