Introduction to Problem based Learning – The AAU Way

A Course given by:

Yiangyun Du
Department of development and planning
Jibigerstraede 13, DK - 9220 Aalborg East
Phone: + 45 96350353, e-mail: xiangyun@plan.aau.dk

Lars Peter Jensen
Department of Control Engineering
Fredrik Bajers Vej 7C, DK - 9220 Aalborg East
Phone: + 45 96358740, e-mail: lpj@control.auc.dk
URL: http://www.control.aau.dk/~lpj

Both Associated Professors at Aalborg University

Monday, the 28th of August 2006: The Aalborg model

9.00 Welcome by lecturer Xiangyun Du and Lars Peter Jensen
9.10 Introduction and presentation of lecturer and participants.
9.20 Discussion of participants expectations (reflection-for-action).
9.30 Introduction to the program.
10.00 Coffee
10.30 PBL as educational model and Practice at Aalborg University
12.00 Lunch
13.00 PBL as educational model and Practice at Aalborg University
13.30 Structure and conditions:
   Structure of Aalborg University
   Working tasks for VIP’s
   Directing the studies
   Teaching task’s
14.00 Coffee
14.30 Intercultural Communication in a PBL environment
16.00 End of day one

Tuesday, the 29th of August 2006: Supervision + courses

9.00 Introduction to role play
9.15 Exercise: Role play of a supervising situation
10.00 Coffee
10.20 Exercise continued
12.00 Lunch
13.00 Supervision
13.45 Courses
   Description
   Syllabus
   Exercises in groups
   Differences between project course (PE) and study course (SE)
15.15 Unanswered questions
15.45 Until next time?
16.00 End of day two
PBL as Educational Model and Practice at Aalborg University

Lars Peter Jensen
Xiangyun Du
Aalborg University

Overview of PBL in general and AAU practice
- Why PBL - Challenges and changes in engineering education
- What is PBL
- PBL principles and theories
- PBL Aalborg Practice
- Students experiences in PBL environment at AAU

Diversity of engineering competences

- Scientific knowledge
- Technical competencies
- Process competencies
  - Project management
  - Communication
  - Teamwork
  - Organization
What kinds of engineers are expected for the future?

Globalized context
- Interdisciplinary knowledge
- Lifelong learning
- Effective communication
- Analytical skills
- Diverse capabilities
- Designing and conducting experiments
- Inter-cultural competences
- Application of mathematics and science knowledge
- Team work
- Project management
- Identity and solving applied science problems
- Social, environmental, and ethical concerns

- National Academy of Engineering, The Engineer of 2020, 2004
- ABET: http://www.abet.org/

Effective communication
- Intercultural competences
- Designing and conducting experiments
- Project management
- Identity and solving applied science problems
- Social, environmental, and ethical concerns

Identity and solving applied science problems
- Team work
- Application of mathematics and science knowledge
- Analytical skills
- Diverse capabilities
- Designing and conducting experiments
- Inter-cultural competences
- Application of mathematics and science knowledge
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- Project management
- Identity and solving applied science problems
- Social, environmental, and ethical concerns

What is problem-based learning?

A learning method based on the principle of using problems as a starting point for the acquisition and integration of new knowledge.

- H.S. Barrows 1982

Educational changes in Denmark

- New study programs: enriched engineering disciplines
- New expectations: broadened engineering skills and competences
- New study forms: implementing student centred and work place-imitated learning environment (for example, PBL as an educational strategy)

New challenges and tasks for educators
A learning method based on the principle of using problems as a starting point for the acquisition and integration of new knowledge.” Barrows 1982

Problems form the focus and stimulus for learning

Problems are the vehicle for development of problem solving skills

New information is acquired through self-directed learning

Student-centred
Small student groups
Teachers are facilitators/guides

What are PBL as abbreviations?
- different meanings of the P

- PBL: Problem based learning
- PBLE: Problem based learning engineering
- PBL: Project based learning
- POL: Project organised learning
- TPL: Total Project Learning (Finland)
- PSBL: Problem, project, product, process and people (Stanford version)
- POPBBL: Problem based and Project organized Learning (Aalborg version)
- Architecture and Design version: Play
Change to PBL—improvement?

- Deep knowledge; better understanding
- Improvement of motivation and engagement among both students and staff

Research results from Thomas (2000)
- Improved subject interest
- Improved engagement and motivation
- Difficult to implement
- Difficult in relation to independency and self-directed learning
- Tendency that the effect of PBL is related to the degree of implementation in the organisation

PBL as educational model
- Learning theories

What is ‘learning’?
Yes, it’s actually true — you can get a degree by repeating everything the teacher says.
Learning Environment - traditional teachers and textbooks as main learning resources

Teaching = Learning?

Levels of understanding - Bloom

Bloom
- Knowledge - memorize
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

Surface learning

Deeper learning
Levels of learning

The one who understands do not need memorising?

PBL Learning Principles
(Kolmos & Graff 2003)

Focuses of education
- Learners
- Contents
- Context
- Processes

Learning
- Problem based
- Contextual learning
- Experience and activity based learning

Social
- Participant directed
- Team based learning

Content
- Interdisciplinary learning
- Exemplary learning
- Analytical thinking - theory-practice relation

Learning is how brain works
- Different individual preferences (Felder 1988)
Learning as internalization

Internalization of social influence

Learning as participation in activities

Experiential learning - Kolb’s learning cycle

Learning is the process whereby knowledge is created through the transformation of experiences - David Kolb 1984
Life Long Learning

To live is to learn
– Chinese saying

Student-centred learning

Self-directed learning: six focuses
(Zimmerman & Lebeau 2000)
• Defining what should be learned
• Identifying one’s own learning needs
• Developing learning objectives
• Identifying a learning plan to achieve those objects
• Implementing the learning plan
• Self-evaluating the effectiveness of the learning

Active learning

• Students learning (a survey report from Felder 1988):
  – 10% of what they read
  – 26% of what they hear
  – 30% of what they see
  – 50% of what they see and hear
  – 70% of what they say
  – 90% of what they say and do

  \[
  \begin{align*}
  \text{passive} & : 10\% + 26\% + 30\% = 66\% \\
  \text{active} & : 50\% + 70\% + 90\% = 210\% \\
  \end{align*}
\]
Organizational context
A model of understanding learning at three levels

Social-cultural context
Organizational context
Individual learning

Becoming a person
Being a citizen
Negotiation of new meanings
Guided participation - interaction
Professional responsibilities
Being a person
Being a citizen
Negotiation of new meanings
Guided participation - interaction
Professional responsibilities

Individual learning
Participation
Interpreting experiences as meaningful
Developing responsibilities
Establishing new practices, values
Reflection on experiences

Professional responsibilities
Negotiation of new meanings
Guided participation - interaction
Professional responsibilities

Social responsibility
Social responsibility

PBL Aalborg Model: Principles of Project-organized problem-solving Learning

‘The Aalborg Experiment – project innovation in university education’ - Kjaersdam & Enemark (1994)

PBL Aalborg Practice
Three main characteristics
- Problem
- Project
- Team work
Team work

What?
• A group of students working together on a project
• They have to both carry out the project and document the results
• Based on the documentation an oral group examination is held, but the marks are individual

Team work

Why?
• A survey in 1997 showed that 75% of the companies wanted new employees to have good skills in team work
• Most engineers work in teams
• The individual student in the group learns from the others (peer learning)
• Responsibility towards the group leads to very hard work
• Group members provide social support, thus lower drop-out rate
Team work

How?

- Each group has a group room
- Group size of 6-8 students first year, 2-3 students last year
- Students are in charge of forming groups
- New groups formed every semester
- Team building courses:
  - Roles, communication, co-operation, conflicts

Projects

What?

- A unique task
- Have a lot of complex activities
- Needs several people with different skills
- Have a final goal/objective
- Limited resources (time, money, people)
- Have to deliver a result at a given time:
  - As a minimum a written report
Projects

Why?
- More and more companies use project organization
- Much engineering work is performed as projects
- Motivates the students and increases student activity
- Secures deep learning in subjects covered in the project
- Improves documentation skills

Projects

How?
- One project each semester
- Necessary theories and methods given in project courses

PBL AALBORG MODEL

- Project courses lectures seminar min. 7.5 ECTS
- Study courses and Lectures – max. 7.5 ECTS
- Examination
- Project – min. 15 ECTS
- Examination

50% 33%
50% 67%
Phases of the project - Seven jumps

(1) clarifying terms and concepts not readily understood;
(2) defining the problem;
(3) analysing the problem;
(4) summarising the various explanations of the problem into a coherent model;
(5) formulating learning objectives;
(6) individual study activities outside the group; and
(7) report and synthesize the newly acquired information.

Project process - an example

Lunch until 13.00
Projects

*How?*
- One project each semester
- Necessary theories and methods given in project courses
- Each group has (at least) one supervisor
- Documentation:
  - a written report, oral defence, (construction)
- Courses in:
  - project management and planning
What is analysis?

Get an overview of the problem
- Asking Questions
- See Perspectives

Divide into different aspects
- Top Down
- Bottom Up

Look critically at all aspects
- Estimate
- Measure
- Compare

How to start analysing – presentation of two tools

- The six W- model

  Why?  What?
  Whom?  Problem
  Where?  How?
  When?

- Post It Brain storm
  1. Everybody writes keywords on Post It notes for 5 min
  2. All notes are placed on the blackboard
  3. All notes are read out
  4. Everybody goes to the blackboard and structures the notes together

Problems

What?
- Three different types of problem based projects at AAU:
  - The task project
  - The discipline project
  - The problem project
The task project

- Considerable planning and control by the supervisors
- The problem and the subject as well as the methods are chosen beforehand
- The educational objectives are easily controlled
- Being a supervisor is easy in that the supervisor knows exactly what is going to be explored in the project and can direct the students’ choices in the planned direction.

The discipline project

- The disciplines and the methods are chosen in advance
- The students have to identify and define a problem within the described disciplines
- The educational objectives are mostly formulated for each discipline
- Being a supervisor in this process may be a bit uncertain, because the students are allowed to make some choices on their own. However, the scientific field is described well and hardly any surprises occur
The discipline project

Problem ↔ Discipline

The problem project

• Based on problems as the starting point
• The problem will determine the choice of disciplines, theories and methods
• The educational objectives emphasises ability to analyse and methodological skills
• The problem has to be chosen within a broader social and technical frame
• Being a supervisor in this process may be difficult because it is a self-directed learning process and the supervisor may find him/herself at the edge of capacity
Common features of project work

• For all three types of projects, a problem has to be analysed and solved by means of different theories and methods
• The phases of the project are common to all three project types

Problems

Why?
• Real world problems are interdisciplinary and complex
• It is a learner-centred process
• It meets the learners' interests and enhances motivation
• It emphasizes development of analytical, methodological and transferable skills

AAU students on problems

• "We are engineers — our responsibility is to solve real technological problems."
• "This is the first time we found a real problem ourselves rather than getting something from supervisors. It is really exciting. It fits my way of learning. I learn better when I find the way myself. This way of learning is much better than only attending lectures, because I have to know why I need to learn this. When I know the objective clearly, I learn much better."
• "When working on a problem, I am strongly motivated and attracted. We need to solve this problem."

Xiangyun Du, 2005
Problems

How?
• The project groups choose their own problem to work with in the projects
• The problem has to be analyzed within a relevant context before it can be solved or analyzed further
• The problem determines the choice of methods and theories to be used

Who is in control of what?

<table>
<thead>
<tr>
<th></th>
<th>Problem</th>
<th>Discipline</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supervisor</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Students</td>
<td>+ (?)</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Discipline Project</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
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<td>(+)</td>
<td>+</td>
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<td></td>
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<tr>
<td>Problem Project</td>
<td>?</td>
<td>(+)</td>
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</tr>
<tr>
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<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

PBL as educational model - practice at AAU students' experiences

Drawing upon multiple learning resources, students take active role creating learning opportunities and managing their own learning
We are engineers, our tasks are to solve problems (Male EE)

Students’ perceptions

We feel easier to learn the technical skills through group work

We are engineers, our tasks are to solve problems (Male EE)

Students’ perceptions

We develop social skills in group work, this improves the learning process

Project work may not give some ideas of what is not going to learn.

I am strongly motivated when working on problems

I am confident in different tasks now after these experiences

This makes our study serious... like real work place (Male EE)

We want to make it possible that we can learn from each other and everybody can learn what they want to learn

We develop ourselves and get mature along the way

We get mental support from each other, it involves lots of responsibility so that we don’t easily drop out (Female A&D)

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Directing the studies

Study Regulations:

• General regulations

Objectives for the M.Sc. (Engineering) Programme

The M.Sc. (Engineering) programme aims to qualify students independently to take care of business functions, nationally as well as internationally, in which they:

1. have to apply scientific methods within the areas of engineering and science, and carry through technical research and development;
2. have to solve complicated technical problems using scientific and technological knowledge;
3. have to participate in the planning, carrying out, and management of complex technological systems and bring about changes in social, economic, environmental, and industrial environments in the solution of technical problems;
4. have to enter into managerial and co-operative relationships with people having different educational and cultural backgrounds.

Furthermore, the M.Sc. (Engineering) programme has to qualify the students to participate in scientific research functions.

Besides, the M.Sc. (Engineering) programme has to qualify the students to participate in managing the technological development to raise the technological level of business enterprises, and to contribute to the development process of business organisations.

Skills to

Confronting new problems
Logical Reasoning
Critical and independent analysis
Interdisciplinary synthesis
Promotion of sustainable technologies
Creative problem-solving
Communications
Group work and co-operation
Entrepreneurship
Management functions
Continuous professional development
4.6. INTELLIGENT AUTONOMOUS SYSTEMS

Objectives and contents of the specialisation

The objectives of the specialisation in Intelligent Autonomous Systems are summarised as follows:

- to provide students with knowledge in modelling of mechanical systems such as spacecraft, ships, and mobile robots,
- enable the student to apply modern methods of control to problems related to autonomous systems,
- to analyse methods of state observation, parameter estimation and sensor fusion in mechanical systems,
- to provide students with a comprehension of supervisory control, fault-tolerant control and fault detection,
- to let students analyse software architectures for autonomous systems.

The courses include necessary general theoretical topics within process control for autonomous systems but modules are also made available in scientific communication and proficiency in English language for those who need it.
SPRING Semester – Intelligent Autonomous Systems
THEME: Modelling and Control
PERIOD: 1 February - 30 June

PURPOSE:
- To give knowledge and comprehension of optimal and robust control theory.
- To give the students the ability to analyse modern control methods for multi-input/multi-output systems.
- To give students the ability to apply modelling methods and control synthesis for advanced mechanical systems.

CONTENTS:
The project is based on a problem of control and supervision of an autonomous system. The model of the mechanical system has to be derived. The vital part of the project is the choice of the set of actuators and sensors for onboard application. Different control strategies have to be investigated and compared. The supervisor system responsible for autonomy onboard has to be designed. The chosen solution has to be implemented on a real time platform and tested, either by the computer simulations or dedicated hardware.

COURSES:
Courses will be given in the field of modelling of mechanical systems, supervisory and fault tolerant control, and modern control theory.

EXAM:
The external oral examination is based on the prepared project documentation. Each student is marked according to the 13-scale.

Directing the studies

Study Regulations:
• General regulations
• Sector’s, lines or specialization’s
  – Objectives and content
• Specific semesters
  – Theme
  – Projects

Model based tracking for navigation

Background
As part of an ongoing research project (with Computer Science AAU and The Danish Institute of Agricultural Sciences) an autonomous vehicle is developed which navigates autonomously in the field. The aim is to reduce the inputs to the field and monitor the growth of the individual plants, thereby providing obvious environmental and economic advantages over more traditional farming.

Purpose
It is important in such applications to both navigate accurately in the field but also to be able to identify individual plants. The aim in this project is to use perspective images captured from a camera mounted on the front of the vehicle to provide estimates of structure of the crop rows as well as position of the individual plants. The focus will not be on the image analysis but on sensor fusion with non-vision sensors mounted on the vehicle e.g. wheel encoders, differential GPS as well as integration of information about the known structure of the field.

The aim is to use all available information on the autonomous vehicle in order to achieve the best possible estimates of the vehicle and individual plant position (in the order of cm).

Methods
The project will include:
- Modelling of vehicle system and plant pattern in the camera image
- Prediction of crop structure based on the system models as well as previous measurements (images and data from sensors)
- Estimation of vehicle's position and orientation as well as plant position
- Algorithms are simulated in the laboratory on simple setup.
- If possible the algorithms are applied to data acquired in the field.
Directing the studies

Study Regulations:
- General regulations
- Sector’s, lines or specialization’s
  - Objectives and content
- Specific semesters
  - Theme
  - Projects
  - Courses

Study related courses (SE):
- Fault Detection and Automated Systems
- Modelling of Mechanical Systems
- Controller Structures
- Modelling of Mechanical Systems II
- Engineering Responsibilities

Project related courses (PE):
- Robust Control
- Optimal Control
- Supervisory Control
- Neural Networks and Fuzzy Logic

Teaching task’s
Structure of a semester:

<table>
<thead>
<tr>
<th>Project courses</th>
<th>Study courses and lectures</th>
</tr>
</thead>
<tbody>
<tr>
<td>lectures seminar</td>
<td>Lecturer/instructor</td>
</tr>
<tr>
<td></td>
<td>Examination Examinoer</td>
</tr>
</tbody>
</table>

Project: 50% - 33%
Lecturer/instructor
Supervisor: Advisor and facilitator
Examiner/censor: Examination