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New contribution to PBL?

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ORIGINS OF PBL
During the 1960s and 1970s several reform universities were established. Some of the reform universities were established with a new educational model. McMaster University, Canada (1969), followed by Maastricht University in the Netherlands (1976) started out with problem-based learning where groups of students learned content knowledge by studying cases. This more case and problem-based learning model was especially applied in medicine – but at Maastricht it was an institutional approach across subject areas (Barrows, 1996; de Graaff & Bouhuijs, 1993). In Sweden, Linköping University was established in 1975 and adopted problem-based learning in medicine in 1986 (Dahlgren, 2002; Hanberger, Persson, & Bergdahl, 2008).

At the same time, Roskilde University and Aalborg University were established in Denmark with a slightly different model called problem-oriented and project-organized learning. For both Danish universities, this was an institutional approach across all faculties and students worked on socially relevant problems as a starting point for projects (Bitsch Olsen & Pedersen, 2005; Kolmos, Krogh, & Fink, 2004).

The Danish models are different from the McMaster and Maastricht model in terms of both the organization of the learning process and the learning product; however, the learning principles behind the models are very similar (Kolmos & de Graaff, 2014). Furthermore, the last 20 years of problem based and project based learning (PBL) implementation around the world indicate that institutions/programmes utilize elements of the two original models as it fits the learning outcomes. Today, the literature clearly indicates that the original models are pragmatically merged and applied in many different ways all over the world – and is mostly referred to as problem and project-based learning (PBL) (de Graaff & Kolmos, 2006; Kolmos & de Graaff, 2014).

PBL reform universities have played a tremendous role in changing higher education and have served as living laboratories in which it is possible to get inspiration.

PBL IN SWEDEN
Sweden has had its own history of PBL and it may not have been the most commonly used student-centred pedagogy. Without claiming that I know the history of PBL in Sweden, there are some landmarks that have been visible from outside Sweden. Linköping University, as one of the reform universities, has introduced new models for teaching and learning, although never as general institutional models. PBL was introduced in the medical field in 1986 as the second medical education to do so following Maastricht (Hanberger et al., 2008). But there have been no institutional PBL approaches—PBL has been implemented more in classrooms, single courses, or individual programmes. As in many other parts of the world, it has been the health area that has utilized the case-based PBL approach. Research on and conceptual development of PBL is found especially at Linkoping University and Lund University (Dahlgren, Hult, Dahlgren, Hård af Segerstad, & Johansson, 2006; Egidius, 1991, 1999).

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During the 1990s, a European network on PBL called UNI-SCENE (University Student Centred Network) was established involving the universities of Linköping, Roskilde, Aalborg, and Maastricht. A few conferences were held in connection to the university anniversaries at Linköping and Maastricht in 1995 and 1996; but after a few other events it ended. These activities was an initiative from management and educational researchers and it was hard to create interest among the university staff to participate as it was during a period where the disciplines dominated as a phase in development, similar to development at McMaster university going from a contextual to disciplinary approach in PBL development (Neville & Norman, 2007). Furthermore, the call for educational reforms coincided with the announcement of the Bologna process in 1999, so the UNI-SCENE network was somewhat too early.

In Sweden, PBL has not really been associated with engineering education to the same degree as it has in Denmark. However, Sweden has contributed worldwide by the development of the CDIO model that was developed by KTH, Chalmers, and Linköping (Crawley, Malmqvist, Östlund, & Brodeur, 2010). CDIO stands for Conceive, Design, Implement, and Operate and is today a worldwide society with more than 120 institutional members. CDIO is much more than PBL as it also involves series of criteria on, for example, faculty training, quality assurance, professional courses, etc. Although there is no claim of utilizing PBL learning principles, there are clear synergies in the teaching and learning approaches between PBL and CDIO (Edström & Kolmos, 2014).

**PBL and Methods of Student-Centred Learning**

PBL has not been the only pedagogy that has dominated educational change. There has been a trend of more student-centred learning activities such as case-based learning, inquiry-based learning, active learning, problem solving, scenario-based learning, etc. (Savin-Baden, 2014). For all of these different models, there are differences in terms of the degree of student involvement in identification of the problem, the role of the teacher, the organization of the learning process, and assessment.

What is really important for a sustainable curriculum is that flexibility is built into the structure. Students should try out different learning methodologies, and by reflecting on the differences they may become more aware of work and learning variations. Reflection on one’s own learning process by comparing different ways of learning has been shown to be very efficient for the learning of process competences such as collaboration, project management, conflict management, etc.

Case-based PBL as practised in many medical schools can mean large investments in the development of cases. To justify such investments, cases will have to last for a long period. Consequently, there is a danger that PBL ends up more like a textbook approach instead of being a self-directed learning approach where students can choose the problems they want to work on. The same lack of flexibility also exists in the project-based approach that is carried out as more task-based projects defined by teachers and given to students. Flexibility in PBL does require that the problems can be new and defined for each project, which indeed also involves students identifying the problems. This more open and participatory approach or self-directed learning is an important element for increasing motivation in learning.

It is this type of learning philosophy that is so important to keep as a guiding principle for the organization of curriculum practice. As PBL and other forms of student-centred learning spread around the world, variation in PBL practices also increases and there are now thousands of hybrid variations of cases versus problems, narrow problems versus open/ill structured problems,
small projects/versus longer projects, etc. Honestly, reviewing the literature and learning about these new practices, it is not always true that students have a participatory and self-directing influence in the learning process and often students’ decisions are narrowed down to a few choices to fit into a narrow discipline approach. Maybe this will be okay as part of an overall scaffolding of students’ learning and introduction to more active learning; however, this will not be based on the PBL philosophy.

Advanced and complex PBL models need to go across disciplinary borders to frame contextual problems and allow students to work on the problems longer than single courses will allow. This does not mean that teachers should not go for more active learning in single courses, but more to emphasize that there is a need for a taxonomy of different types of student-centred learning methodologies going from small cases in single courses to a more comprehensive institutional case-based PBL model or a problem-based and project-based model.

PBL, RESEARCH, AND ENGAGEMENT
Another aspect I think is very important to stress is that change to PBL is not about beliefs or attitudes – it is about research, documentation, and evidence of improvement of student learning. There is research documentation that improvement of skills and competences can be found within several educational programmes (Dochy, Segers, Van den Bossche, & Gijbels, 2003; Hmelo-Silver, 2004), deeper learning strategies and an increase of perceptual motivation (Bell, 2010; Galand, Bourgeois, & Frenay, 2005; Galand, Raucent, & Frenay, 2010), and even higher grades (Graham, 2012). The research literature on PBL is extensive, although there are a substantial number of case descriptions as well belonging more to categories of best practices.

Of course engagement and involvement are two very important elements when implementing PBL among academic staff and students. No matter if it is at a narrower course level or at a departmental level, a change of teaching and learning methods will only happen if there are engaged change agents and academic staff involved. Knowledge of new methods for teaching and learning is another critical aspect combined with the need for training. It is crucial to train staff and let staff experience new practices (Kolmos, 2002).

THE ARTICLES IN THIS ISSUE
There are four contributions in this special issue on PBL. As such these contributions reflect some of the current research questions within existing PBL frames on how to practise a more student-centred learning curriculum.

The first contribution by Donnér and Edgren summarizes some of the literature on PBL. They have conducted a literature review to determine the question if PBL is a better way to teach and learn. Their answer is yes – if PBL is properly implemented – and this involves a systematic approach to the curriculum where PBL is not only used heuristically in a single course by one teacher, but also serves as an integrated part in an entire curriculum.

The second contribution is written by Setterud, Johansson, Edgren, Amner, Person, Segersten, Uhlin, and Lidskog and focuses on the training aspect by comparing four different types of tutor training for PBL. The trainings share a lot of the same theoretical elements and training for practice, but the design of the courses is different. The response from the participants indicates that no matter the course design, there seems to be widespread satisfaction with the introductory workshops to tutoring. What this result really indicates is that academic staff need training for new educational practices in the classroom and there is not a lot of research on training or the impact of training.
The third article is in Danish written by Winther Hansen and Hatt. They report on an experiment with inter-professional learning within a PBL frame where they have integrated role-play. The results indicate that the combination of PBL and role-play where students have the possibility of acting is a very fruitful way of learning inter-professional skills and competences.

The fourth article reports on pre-PBL experiments in the classroom. Wedelin and Adawi experiment with alignment of case-based reasoning and cognitive apprenticeship in a course on mathematical modelling with the argument that scaffolding in PBL is important and that there should be stages of student centred learning like problem-solving before introducing PBL to students.

ARE THESE NEW CONTRIBUTIONS?
There is a lot of literature on PBL, and as such it is also relevant to ask if this issue contributes new knowledge to the pool of existing research knowledge? My answer would be yes and no. Yes, this is new knowledge as it reflects state-of-the-art of PBL research and development in Sweden with contributions from Denmark. It indicates that PBL is widely used by several universities and in several programmes, and that there is a Swedish history for PBL that may not be known worldwide. On the other hand, the articles do not contribute any new theoretical insights or new research results, but confirm already existing knowledge and there is a lot of research that does the same.

However, this issue could create a new start by re-activating debates on student centeredness and how to develop a learning philosophy that underpins this goal. It could be beneficial to cross medicine/health, social science, humanities, science, and technical subjects to extract and conceptualize the core learning principles. What matters is how the learning process meets students’ cognitive and emotional pre-requisites and transforms this into relevant and future-oriented knowledge, skills, and competences.

REFERENCES


Problembaseret læring og forumspil som motiverende læringsmetoder og fælles samarbejdsform i interprofessionel undervisning

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I denne artikel fremlægger vi en undersøgelse af effekten af at bruge PBL med forumspil i interprofessionelle læringsforløb og vi diskuterer hvorfor disse metoder støtter studerendes og underviseres motivation for at indgå i et interprofessionelt læringsforløb. Undersøgelsen blev foretaget via tilrettelæggelse og gennemførelse af et konkret, interprofessionelt undervisningsforløb for to klasser omkring temaet "konfliktløsning" ud fra en PBL-ramme. Der blev foretaget dataindsamling via spørgeskema- og interviewundersøgelse, samt supplerende kvalitative dataindsamlingsmetoder, for at opnå indsigt i både kvantitative og kvalitative aspekter af studerendes og underviseres vurdering af forløbet og metoderne. Undersøgelsen peger på at PBL-metoden kan give et fælles og udviklende afsæt for underviserne og danne basis for meningfuldt gruppearbejde for de studerende. De studerendes aktive deltagelse stimuleres og den personlige feedback til de studerende, der arbejdes med i vejledningerne, er stærkt motivierende og engagerende. Samtidig opnår de studerende at tilegne sig en ny, og, for de fleste studerende, anderledes studierummet, der kombinerer teorien med mere personlige og følelsesmæssige aspekter, det skaber bevidsthed om egne følelser og opmærksomhed på betydningen af en anerkendende tilgang. Resultaterne viser at PBL med forumspil kan være relevante metoder at anvende i interprofessionelle undervisningsforløb hvor manglende motivation og ringe deltagelse blandt studerende er fremherskende.

Keywords: problembaseret læring, interprofessionel læring og samarbejde, motivation, læringsprocesser, forumspil

INTRODUKTION


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Kravet om øget udbud af IPE stiller samtidig uddannelsesinstitutionerne overfor en række udfordringer, der omhandler mange forskellige forhold - lige fra optimal organisering af IPE, til samarbejds krav til undervisere som er vant til monoprofessionelle forløb med en egen pædagogisk didaktisk logik, og til studerende som ikke kan se mening af at skulle bruge studietid på at samarbejde med andre studerende fra andre fag. IPE, hvor der skal etableres forløb på tværs af professioner, er en særlige udfordrende didaktisk opgave. Det er en uafsluttet teoretisk diskussion og praktisk udfordring, hvor i et uddannelsesforløb f.eks. interprofessionelle uddannelseselementer optimalt placeres (Curran, Sharpe, Flynn, & Button, 2010; Derbyshire, 2011; Oandasan & Reeves, 2005), hvilke uddannelser, der har udbytte af at studere sammen, hvilke metoder og læringskontekster, der bedst kan bringes i anvendelse i interprofessionel undervisning (Jakobsen, Hansen, & Eika, 2011) og hvilke effekter IPE overhovedet har (Curran et al., 2010; Derbyshire, 2011).

Nærværende undersøgelse afspæder behovet for undersøgelse af pædagogiske og didaktiske forhold for specifiket det interprofessionelle felt, med afsejt i spørgsmålet: Hvad er hensigtsmæssige metoder i IPE med henblik på at motivere og engagere de studerende i aktiv deltagelse, herunder understøttede samarbejde og videndeling blandt undervisere?

Undersøgelsen tilstræber specifikt at øge indsigten i hvordan og hvorfor dybdelæringsperspektivet, læring i grupper, og metoden forumspil, i et interprofessionelt PBL-forløb, kan bidrage til motivation og højt læringsudbytte for de studerende. Argumenter for at anvende PBL i IPE er fremhævet af bl.a. Dahlgren og Thompson (Dahlgren, 2009; Thompson, 2010), hvorfor artiklens fokus ikke er at argumentere for selve koblingen, men at uddybe hvordan metoderne understøtter motivation og deltagelse. Koblingsmuligheder mellem forumspillet og IPE er mindre velbeskrevet.

Professionshøjskolen Metropol har haft studerende i interprofessionelle undervisningsforløb på tværs af op til 10 professioner siden efteråret 2009. Det interprofessionelle forløb ”3 uger tværgående undervisningsforløb” danner afsæt for det pædagogiske projekt og undersøgelse, der beskrives i det følgende. Fra første gang dette undervisningsforløb blev afviklet, blev det klart at det var en massiv udfordring at etablere forløb, der gav mening på tværs af uddannelserne, kunne samle underviserne omkring tilrettelæggelsen, motivere de studerende og engagere dem i aktiv deltagelse.

Af disse erfaringer udsprang et ønske hos flere undervisere om fordybelse og kompetencudvikling indenfor pædagogiske metoder, der kunne samle og motivere de studerende. Problembaseret læring (PBL) med inddragelse af forumspil blev udvalgt af nogle undervisere som den metode der var særlig interesse for at arbejde med.

Samtidig muliggjorde PH Metropol deltagelse i Det erhvervsrettede Uddannelseslaboratorium' igangsættelse af projektet ”PBL med inddragelse af forumspil som motiverende og samlende læringsform i tværgående undervisning”.

Ud fra behovet for at undersøge relevante læringsformer i IPE udsprang følgende hypotese for projektet og undersøgelsen:

"PBL med inddragelse af forumspil som læringsform skaber motivation og aktiv deltagelse blandt studerende i tværgående undervisningsforløb. Udvikling af underviserne arbejdsformer og praksis på baggrund af konkretes undervisningsmetoder baseret på PBL til skabe et attraktivt og dynamisk studiemiljø hvor de studerendes tværpresseionale kompetencer styrkes".

På et 3-ugersforløb omkring temaet “Konflikthåndtering”, afholdt i september 2013 med deltagelse af 8 professioner, afprøvedes følgende konkrete PBL koncept:

- Underviserne fik sparring af intern PBL-konsulent i at tilrettelægge og gennemføre et PBL-basert forløb
- Forløbet var tilrettelagt med PBL-gruppearbejde og færdighedsøvelser
- Der blev anvendt forumspil som en del af et PBL-baseret læringsforløb.

TEORETISKE RAMMER FOR OG UNDERVISNINGSFORLØBET MED PBL OG FORUMSPIL

PBL og forumspil er active eksperimentale læringstilgange hvor undervisningsprincipperne først og fremmest er handlingsorienterede. Det betyder at de studerende arbejder i en eksperimenterende og reflekteret undervisning og at de derved lærer gennem egne oplevelser, vidensøgning og formidling.


PBL er designet for at hjælpe de studerende med:

- udvikling af klinisk ræsonering,
- selvstyrede læringsfærdigheder,
- videnskabelig arbejdsmetode,
- udvikling af en sikker vidensbase,
- evner til livslang læring,
- samarbejdsevner,
- strukturering af viden til senere brug i den kliniske kontext,
- ansvar for fremstiftning hos sig selv og det omgivende samfund,
- udvikle studerendes evne til refleksion, selvvurdering, og realistisk målsætning.

(H. S. Barrows, 1988)

I en problembaseret læringstilretteleggelse udfordres den studerende gennem et problem/situationsbeskrivelse til at finde mulige forklaringer på problemet, og den studerendes læring har større fokus end underviserens formidling.

Gruppearbejdet i PBL er karakteriseret ved samarbejde, deltagerstyring, vidensudveksling, refleksion og gensidig feedback og på at arbejde med autentiske problematikker.

Arbejdet i PBL-gruppen adskiller sig fra traditionelt gruppearbejde ved at arbejdsformen imellem møderne i grupperne er selvstudium, og gruppen fungerer som forum for dialog og diskussioner, der udvikler den enkelte studerende, såvel personligt som fagligt.

I PBL anvendes begrebet professionsrelaterede problemer for at tydeliggøre, at “problemerne” hentes ind fra virkelige og arbejdssforbundne sammenhænge. Når man arbejder med problemet, vil man tilegne sig erhvervsspezifiske kundskaber, ligesom man vil udvikle problemalsningsstrategier og -kompetencer, som er direkte relateret til den professionelle handlingskompetence.

Når studerende arbejder med problembaseret læring udvikler de dybdelerings strategier- de lærer på et dybdeleringsniveau (Marton & Säljö, 1976; Trigwell, Prosser, & Waterhouse, 1999).


PBL er både en pædagogisk fremgangsmåde og en curriculum design metode, og kan dermed spænde over forskellige læringsselementer som f.eks. projektarbejde, forumspil, feltarbejde, formidling og en række andre former, helt afhængig af formålet og de til rådighed værende midler, og omfanget af de problemfelter der arbejdes med.


Praksis i Danmark er i høj grad inspireret af Katrin Byréus. Byréus er en svensk dramapædagog og ifølge Byréus er formålet med forumspil, at tilskueren transformeres fra passiv beskuer til aktiv deltager. Forumspil giver mulighed for at træne til virkeligheden på en ufarlig måde (Byréus, 2001). I dag anvendes forumteater og forumspil i uddannelse og organisationer til at folk kan øve sig i at handle (underledes). Forumspil bidrager til et fælles referencegrundlag, og skaber et forum, hvor der kan reflekteres i fællesskab.

Der er ikke så mange studier, der specifikt omhandler forumspil, men mange uddannelser bruger rollespil for at indbygge aktiv læring. Der er en del studier der rapporterer at rollespil virker positivt for studerendes læring, at det er en metode der giver mulighed for at få en dybere forståelse af et problem og stimulerer yderligere interesse for emnet (Rao & Stupans, 2012; Ruhanen, 2006). I nærværende undersøgelse er der arbejdet ud fra en forståelse af forumspillet som havende mange lighedspunkter med rollespillet, som f.eks.: fælles synligt læringsrum, ”her-og-nu” refleksioner og et udgangspunkt i ”som om” situationer, hvorfor undersøgelser omkring rollespil inddrages. Rollespil fremhæver dilemmaer og værdier, som ellers kan være svære at belyse og forstå. Normalt nævnes rollespil som en pædagogisk metode, der oger bevidstheden om virkninger og konsekvenser. Bevidstheden om, hvordan vi handler og kommunikere i
social interaktion, øges, og metoden bruges derfor ofte i situationer, hvor værdier, holdninger og følelser er i fokus. Disse er i langt højere grad synlige gennem både verbalt og kropsligt sprog og kan fortolkes gennem en sproglig bearbejdning i konteksten (Alkin, 2002).

**PBL forløbet var udført på følgende måde:**

**PBL forløbene var bygget op over følgende processer:**
- Præsentation af problem/ situationsbeskrivelse
- Identifikation af facts
- Generering af hypoteser
- Definere læringsområder og læringsbehov
- Studier på egen hånd
- Diskussion ud fra ny viden fra litteratur og praksis
- Formidling. Opsamling på hvordan læring relaterer sig til problemet
- Personlig og faglig evaluering/ vurdering, af den enkelte og af gruppen

(forøget af (Hmelo-Silver, 2004))

Forumspil var placeret som en heldagsundervisning sidst i 3 ugers forløbet. Temaet var konflikt håndtering og målet for dagen var, at de studerende opøvede kompetencer i konflikt håndtering og i at finde og afprøve løsningsmuligheder i vanskelige situationer. Emnerne der blev arbejdet med, valgte de studerende selv ud fra oplevede situationer fra deres praktik.

Forumspillet bestod af fem forskellige procestrin: Introduktion, opvarmning, emneudvælgelse, gruppearbejde og selve forumspils scenariet.


**DESIGN, METODE OG MATERIALE**
PBL-teknikkerne beskrevet ovenfor blev afprøvet i 2 “forsøgsklasse” af hver ca. 30 studerende.

I 6 “sammenligningsklasser” gennemførtes undervisningsforløb omkring det samme tema, men hvor underviserne planlagde forløbet uden PBL-ramme, uden forumspil som fast element, uden fælles tilrettelæggelse og uden sparring ved konsulent. Alle 8 hold var administrativt sammensat, efter hensyntagen til mest mulig jævn repræsentation af deltagende professioner. Andre faktorer, som f.eks. køn og alder, spillede ikke ind i sammensætning af holdene og er ikke inddraget i analyse af data.
I de 8 interprofessionelle klasser deltog studerende fra følgende professioner:

<table>
<thead>
<tr>
<th>Uddannelse</th>
<th>Antal studerende, samlet på alle 8 hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ernæring og sundhed</td>
<td>20</td>
</tr>
<tr>
<td>Fysioterapeut</td>
<td>24</td>
</tr>
<tr>
<td>Ergoterapeut</td>
<td>13</td>
</tr>
<tr>
<td>Bioanalytiker</td>
<td>18</td>
</tr>
<tr>
<td>Radiograf</td>
<td>8</td>
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<tr>
<td>Jordemoder</td>
<td>6</td>
</tr>
<tr>
<td>Sygeplejerske</td>
<td>88</td>
</tr>
<tr>
<td>Folkeskolærer</td>
<td>72</td>
</tr>
</tbody>
</table>

Figur 1: Deltagende professioner i forløbet 3 uger tæværende, tema: Konflikthåndtering, efteråret 2013

De deltagende undervisere i forsøgsklasser foretog fælles planlægning af undervisningsforløbet på en fastlagt møderække. Undervisere fik i forberedelsen sparring fra den interne PBL-konsulent, som medvirkede til at udarbejde undervisningsplanerne og sikrede deres PBL-basering. Den interne PBL-konsulent medvirkede til materialeudarbejdelse (herunder cases og teknikker), og underviserne modtog, undervejs i undervisningen, supervision fra PBL-konsulanten. Underviserne modtog herudover undervisning i gennemførelse af forumspil ved ekstern konsulent på en workshop over to dage med tid imellem til at afprøve metoden.

Dataindsamlingen i eksperimenteret var både kvalitativ og kvantitativ. Dette blev valgt for at få den bredest mulige dataindsamling, og for at få flest mulige perspektiver og nuancer med i vurderingen af indsatsen.

Der blev indsamlet data om de studerendes oplevelse af forløbet via spørgeskemaudsendelse for at få mulighed for at få feedback fra den samlede studentergruppe og for at kunne sammenligne grupper af studerendes vurdering af en række fælles spørgsmål.

I alt 256 studerende modtog spørgskema til slutevlauer og af 3 ugers forløbet den sidste dag i forløbet. Alle 8 klasser modtog samme spørgskema, hvor de blev bedt om give en samlet vurdering af forløb, fagligt udbytte, sammenhæng i forløb og relevans for egen uddannelse2. Den samlede svarprocent (RR) var på 48%, hvilket vurderes tilfredsstillende. Efterfølgende blev der genereret rapport over spørgskemaundersøgelse, hvor resultater fra de to forsøgsklasser lagt sammen blev sammenholdt med resultater fra de seks sammenligningsklasser lagt sammen.

For at opnå uddybende indsigt i de studerendes og underviserens oplevelse af forløbet arbejdedes der yderligere med følgende kvalitative dataindsamlingsmetoder:

- Undervisere førte logbog i forløbet
- Der blev afholdt mundlig dialog i de to forsøgsklasser efter fremlæggelser på forløbets sidste dag
- Der blev, efter forløbet, foretaget kvalitative, semistrukturerede interviews med de underviserer, der havde haft forsøgsklasser.

2 Spørgskema bestod af i alt 14 spørgsmål til forløbet. De studerende blev bedt om at besvare spørgsmålene ved at angive en talværdi mellem 1 og 6, hvor 6 var udtryk for den højeste tilfredshed.

RESULTATER
Det viste sig, at de to forsøgsklassers vurdering af tilfredshed, fagligt udbytte, sammenhæng og relevans af forløbet, samlet set var markant mere positiv end vurderingen i de seks sammenligningsklasser. Figur 2-5 viser de studerendes respons omkring overordnet tilfredshed og fagligt indhold.

**Figur 2**

Forsøgsklasser Hold A+B (N=48)

<table>
<thead>
<tr>
<th>Hvordan vurderer du: Din overordnede tilfredshed med forløbet?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Laveste tilfredshed 7%</td>
</tr>
<tr>
<td>2. 17%</td>
</tr>
<tr>
<td>3. 22%</td>
</tr>
<tr>
<td>4. 30%</td>
</tr>
<tr>
<td>5. 24%</td>
</tr>
<tr>
<td>6. Højeste tilfredshed 0%</td>
</tr>
</tbody>
</table>

**Figur 3**

Sammenligningsklasser Hold C-H (N=68)

<table>
<thead>
<tr>
<th>Hvordan vurderer du: Din overordnede tilfredshed med forløbet?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Laveste tilfredshed 14%</td>
</tr>
<tr>
<td>2. 16%</td>
</tr>
<tr>
<td>3. 15%</td>
</tr>
<tr>
<td>4. 29%</td>
</tr>
<tr>
<td>5. 21%</td>
</tr>
<tr>
<td>6. Højeste tilfredshed 10%</td>
</tr>
</tbody>
</table>
De kvalitative data, der blev indsamlet både fra studerende og undervisere, understøttede og uddybede fundene fra spørgeskemaundersøgelsen. Ud fra de kvalitative data kan der både trækkes resultater ud vedrørende PBL og forumspil som metoder i interprofessionel undervisning.

Ved en tematisering af de studerendes kvalitative vurdering af forløbet√udskiller tre overordnede temaer sig i forhold til PBL som arbejdsmetode, som havende særlig betydning for de studerendes positive vurdering af forløbet:

- Motivation og samarbejde i grupperne.
- De fleste studerende havde ikke mødt PBL før i deres studie og der er mange kommentarer, der viser at de var interesserede i metoden og positive overfor dens anvendelse i det tværgående undervisningsforløb. Uddybende beskriver de at læringsmetoden skabte motivation, ansvar for læring og at PBL understøttede det gode samarbejde i grupperne og sammenholdet mellem de studerende.

3 Data fra afsluttende dialog på holdene samt kommentarer i spørgeskemaet.
Högre utbildning

"PBL giver ansvar for egen læring, skaber godt sammenhold i gruppen, giver ansvar i forhold til gruppen. Det øger motivationen, at de andre er afhængige af mig."

• At lære at lære.
De studerende beskriver hvordan de lærte at lære. De udtaler b.l.a. at det var engagerende at arbejde ud fra hypoteser og at det, at skulle forholde sig kildekritisk til den litteratur de fandt, gav træning i at finde andet brugbart materiale. De beskriver også at de lærte ved at skulle undervise og diskutere i PBL gruppen og at ”videns opsamlinger” gav dem indblik i hvad de manglede at lære.

Metoden vurderes af flere til at give et godt fagligt udbytte, skabe gode muligheder for videndeling i gruppen og skabe særlig opmærksomhed på egen indsats:

"Vejledningstimerne - det er helt klart her jeg har fået mest fagligt ud af det, da man her selv skulle "undervise" de andre i gruppen, og formulere det man havde læst og forberedt hjemme. Derudover fik vi nogle gode diskussioner ud af det."

"Vejledningstimerne har været rigtig gode, godt at være en lille gruppe og sidde og arbejde med en vejleder. Til forskel fra en undervisningssituation hvor man er meget mere passiv"

• Mulighed for differentieret læring.
De studerende i forløbet kom dels fra meget forskellige uddannelser med vidt forskellige faglige interesseområder og udgangspunkter, dels var de studerende heller ikke i lige grad vant til selv at skulle være aktive, opsøgende og kritiske i undervisningsforløb.

PBL oplevedes som en mulighed for den enkelte for at arbejde på sit eget niveau og udvikle sin faglige forståelse derudfra:

"PBL - rart at få lov til at vælge hvad man vil fokusere på og også rart at kunne vælge litteratur selv - giver mulighed for differentiering".

Udfordringer
De kvalitative data viser samtidig, at de studerende også oplevede udfordringer i mødet med en ny læringsopfattelse og metode. Omkring PBL fremhæves af nogle, at det stillede højere krav til læsning og at et 3 ugers forløb er kort tid til at lære metoden at kende.

Metoden oplevedes også udfordrende i forhold til den grad af selvstændighed, der fordres:

"Det er svært selv at skulle finde viden, det kræver selvdisciplin".

De deltagende underviseres vurdering af forløbet supplerer de studerendes udsagn i betydningen af at arbejde med PBL. I interviewdata træder følgende temaer klart frem:

• PBL motiverede de studerende til aktiv deltagelse.
  "Fantastisk god måde at arbejde på – nærværende og engagerende studerende".
De studerende beskriver af underviserne som velforberedte og engagerede i at dele og diskutere deres erhvervede viden. Og næsten alle studerende kom ifølge underviserne til PBL-vejledningerne og formidlingerne.

De studerende udviklede personligt engagement i processen og gruppesamarbejdet. De tilegnede sig en studiemetode, og det at give hinanden feedback til PBL-vejledningerne fremhæves som at have en særlig stor betydning for læring, motivation og deltagelse. Underviserens feedback til den enkelte og til gruppen var også helt central for de studerende.

- **Stimulerende læringsmiljø.**
PBL vurderes af underviserne til at være en særlig brugbar metode i det tværgående undervisningsforløb. Metoden beskrives som “effektiv, produktiv og relevant”

  De studerende engageredes kontinuerligt og tog ansvar for gruppearbejdet og egen læring. “De bliver selv til små underviserne”. Underviserne vurderer, at der udviklede et stimulerende læringsmiljø, hvor de studerende selv var aktive i vidensproduktion.

**Udfordringer.**
Underviserne oplever samtidig, ligesom de studerende selv, at metoden også rummede udfordringer. De peger på, at hos nogle studerende skabte metoden modstand – nogle studerende beskrives som vant til “at få det serveret”. De blev usikre overfor krav om at skulle tage ansvar og være aktive selv.

  De studerendes vurdering af forumspil som metode havde følgende temaer:

- **Forumspil motiverer.**
  Data viser stor tilfredshed med metoden og der er mange udsagn, der entydigt peger mod metodens anvendelighed i undervisningsforløbet.

  ”Uundværligt. Godt at øvelserne tager udgangspunkt i vores egen situation”

- **Praksisnærhed.**
  Data viser, at forumspillet udmærkede sig ved at udgøre en særlig mulighed for teori- og praksiskobling, hvor teorien blev særligt meningfuld for de studerende, idet den kunne ”ses” og afprøves i en praksisnær situation. De studerende oplevede at få mulighed for at ”øve sig”.

  ”Det har været rigtig givtigt at arbejde konkret med cases i praksis, som f.eks. praksisøvelser og forumspil. Det har været godt at få brugt sin teori viden i praksis for at se hvor meget der har hængt fast af teorien”.

  ”Forumspil er en perfekt måde at få indsigt i konflikters struktur og opbygning, så man kan arbejde konstruktivt med dem”.

- **Kropsligt og erfaringsbaseret.**
  Forumspillet som metode blev vedkommende for de studerende idet den trak på deres egne, personlig og private erfaringer. Den studerende fik mulighed for at deltagte i aktiviteten med flere facetter af sin personlighed end den akademiske hvorved både engagement og nuancering af læringsudbytte opnåedes.
"Forum spillet er en god måde at afprøve på- kropsligt!"

"Indsigt ved at mærke konfliktens natur "på egen krop" ved at spille/lege konflikter."

Tematisering af underviseres vurdering af forumspillet som metode støtter op om dette:

• Betydning for de studerende.

• Hvorfor virkede det?
Forumspillet beskrives som en intuitiv, god måde at lære på. De studerende kunne mærke hvordan de reagerede følelsesmæssigt og kropsligt. Det var motiverende, fordi det var konkret og tog udgangspunkt i studerendes egne dilemmaer.

Udfordringer.
Undervisernes vurdering kaster her lys over nye aspekter ved anvendelse af forumspillet som metode, idet de studerende ikke selv formulerer nogen kritik af metoden. Undervisernes bemærkninger viser imidlertid, at der også ved denne metode var udfordringer og aspekter, der må reflekteres over: Metoden oplevedes som grænseoverskridende for nogen studerende, det krævede at de havde mod og lyst til at gå ind og deltage og "lege" med rollespil. Underviserne diskuterer, at studerende som har dårlige erfaringer med rollespil måske falder fra eller holder sig udenfor, hvilket underviserne også mener kunne ses på fremmødet de dage, hvor aktiviteten var planlagt.

Opsamling af resultater.
PBL og forumspil kan være relevante metoder at anvende i interprofessionelle undervisningsforløb hvor manglende motivation og ringe deltagelse blandt studerende er fremherskende. PBL-metoden kan give et fælles afsæt for underviserne og giver mulighed for meningsfuldt samarbejde. Den personlige feedback til de studerende er stærkt motiverende og engagerende og de studerendes aktive deltagelse stimuleres. Samtidig opnår de studerende at tilegne sig en studie og læringsmetode.

Forumspillet kan meget relevant kobles til PBL-tilgangen, de studerende oplever at det kobler teori og praksis, og oplever metoden som meget motiverende. Forumspillet skaber bevidsthed om egne følelser og omkring betydningen af en anerkendende tilgang og at medvirke til at skabe et godt og trygt læringsmiljø. Det kombinerer teori med personlige og følelsesmæssige aspekter.

De studerende og underviserne oplever samtidig nogle udfordringer ved at arbejde med metoderne. I forhold til PBL handler de væsentligste udfordringer om usikkerhed i mødet med nye metoder, tid som en betydelig faktor, og vanskeligheder med at håndtere forskelligheder i arbejdsgrupperne.

Forumspillet kan virke afskærende på nogle studerende og frafald kan opstå, når dette skemalægges. Også for underviserne er det udfordrende metoder at arbejde med, de kræver træning, tryghed og overblik, samt rammer, der understøtter aktiviteterne.
DISKUSSION


Undervisningen var tilrettelagt med henblik på læring, motivation og kompetenceudvikling og tog udgangspunkt i virkelighedsnære situationer som den studerende kunne relaterer sig til og møde i egen professionspraksis. Læringen tog i nogle situationer udgangspunkt i overskridende former for læring. Læringsmetoderne udgjorde en mulighed for at de studerende arbejdede med og blev udfordret på deres forståelse. De studerende blev opmærksomme på eventuelle uoverensstemmelser mellem deres eksisterende forståelse og de nye sammenhænge der fremtrådte i læringssamfundet.


På aktørniveauet, blev der opnået et givende samspil mellem studerende og vejleder i PBL-forløbet, idet vejleder, ud fra metoden, forholdt sig til både individets og gruppers proces, det faglige niveau, og selve det at være i en læreproces. Der skete en deltagiggørelse og ansvarliggørelse-af de studerende i deres eget læringsforløb. Der studerende kunne få en ny oplevelse af egen og undervisens rolle.

Udgangspunktet var at de studerende skulle opgive ideen om, at man lærer ved at nogen serverer tingene for en og lade den erstatte af en erkendelse af, at man i stedet er afhængig af sin egen indsats. Der blev insisteret på deres aktive deltagelse, de skulle anvende deres viden, diskutere den og give samt få feedback på den. I forhold til forumspillet opnåedes ligeledes nogle særlige resultater idet det var en situation der løsnede op for de vante roller - alle kom ud over egen ”comfort-zone” og der opstod en nærhed, sensibilitet og omsorg for hinanden, som påskønnes af både studerende og undervisere.

Underviserne fik (ressource- og tidsmæssigt) mulighed for at udvikle og tillegne sig en ny læringstilgang og methode og i samarbejde derudfra udarbejde et fælles nyt undervisningsforløb som gjorde at de flyttede sig fra vanlige pædagogiske og faglige måder at ”gøre” undervisning på. Lære- og udviklingsprocesser handler ikke kun om at lære noget nyt, men også i høj grad at aflære sin vanlige praksis og forståelse. For at kunne udvikle sig, må man, som Pernille Bottrup udtrykker det: ”…. 'vikle sig ud' af den måde man plejer at tænke og göre tingene på” (Bottrup, 2001). PBL
og forumspil blev en fælles sammensætning formidlet og dannede udgangspunkt i det interprofessionelle samarbejde. Det fælles samarbejdsform betød, at de hævede sig op over faggrænses, egne faglige kæmpeste, de blev optagede af ny metode og blev mere parate til at indgå faglige kompromiser. Det medførte et styrkset samarbejdet på tværs af professionerne omkring undervisningen og at der blev åbnet op for et kollegialt læringsrum hvor der var mulighed for udveksling og supervision.

Rammemæssigt blev underviserne støttet i at samarbejde på tværs idet de fik væsentligt øgede tidsmæssige ressourcer og mulighed for at ændre i fastlagte ramme omkring forløbet.

Underviserne blev støttet via samarbejdsmøder med tilkobling af intern PBL-konsulent i forløbet som kunne bistå i den pædagogiske udvikling og bl.a. supervisere den enkelte og være "mester“ ved at vise den konkrete vejledning. Facilitering af IPL forløb beskrives i undersøgelse af Lindqvist & Reeves (Lindqvist & Reeves, 2007) som en kompleks og krævende aktivitet som bedst understøttedes af regelsmæssige debriefing møder.

Denne undersøgelse har specifikt beskæftiget sig med anvendelsen af PBL og forumspil som læringsmetoder i interprofessionel undervisning og som samarbejdsform for såvel studerende som undervisere. Koblingsmuligheden mellem PBL og IPE er velunderbygget (Barr, Koppel, Reeves, Hammick, & Freeth, 2008; Dolmans, De Grave, Wolfhagen, & Van Der Vleuten, 2005). Forumspil er som før omtalt meget lidt beskrevet, dette perspektiv forekommer relevant at undersøge videre.


Metodisk kunne det være spændende at gentage projektet og lade forsøget udvikle sig og se om den positive effekt ville holde. De positive resultater er måske prægede af nyhedens interesse og energi for de studerende og underviserne. Ikke mindst kunne det være spændende at have mere fokus på hvordan man klæder nye undervisere på at håndtere rollen som PBL undervisere samt hvordan forskellige professioner forholder sig til PBL.

PERSPEKTIVERING OG IMPLIKATIONER

De tendenser, fund og mærker som fremstår i denne undersøgelse kunne pege på at uddannelsesinstitutioner i arbejdet med interprofessionelle forløb med fordel kunne prioritere at udvikle et samlende, pædagogisk didaktisk grundlag som fremmer en mere inddragende, handlingsorienteret og udviklende pædagogisk kultur og praksis.

Forløbet viser, at hvis en institution har ønske om at arbejde med at udvikle undervisernes praksis, er det vigtigt at være opmærksom på underviserens egne læringsforståelser. Selvom underviserne i dette udviklingsarbejde var motiverede for ændringer i deres praksis kræver det tid og et stort refleksionsarbejde at arbejde med en udvikling af læringsforståelserne hos underviseren. Selv om deltagerne var motiverede for ændringer var det alligevel vores erfaring at gamle vaner og måder at undervise på dukker op igen og er svære at slippe. Det ”private rum”, som en undervisers praksis på nogle måder kan karakteriseres, har en vis karakter af uforlighed. Supervision er dermed ikke altid hverken virksomt eller ønsket (Illeris, 2006).

Samtidig træder undervisernes behov for mesterlærer/makkertræning tydeligt frem i undersøgelsen. Undersøgelsen peger også på, at det kræver tid, ressource og øvelse, når undervisere skal arbejde med nye metoder. Dette er nødvendigt for at underviserne kan tillegne sig og blive trygge ved de nye metoder. Åbne læringsrum for undervisere kan med fordel opdyrkes og understøttes.
REFERENCES


Warming up for PBL: a course in mathematical modelling and problem solving for engineering students

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The step from traditional teaching to PBL is considerable and it has previously been proposed that students should be skilled at problem solving before entering a PBL course. In this paper, we first discuss some key ideas behind the design of a successful course in mathematical modelling and problem solving for engineering students. A central aim of the course is to help the students to understand the power of learning by exploration, a missing key component in the students’ ability to solve problems. We then discuss how this kind of course can serve as an intermediate step in a progression towards more self-directed project-based and problem-based learning.

Key words: PBL, problem solving, mathematical modelling, engineering education, progression

INTRODUCTION

Engineering education has been criticized for neglecting to demonstrate the relevance of the topic being taught (Prince & Felder, 2006; Prince & Hoyt, 2002), and for neglecting to provide students with opportunities to develop skills that are essential for dealing with complex real-world problems related to science and technology (Litzinger et al., 2011; Woods et al., 1997). These issues seem to be particularly grave in the mathematical education of engineers, where students – at least in some specializations – have significant difficulties in connecting and applying what they have learnt in introductory mathematics courses (Adawi et al., 2005; Wedelin et al., 2014), sometimes leading to the belief that mathematics is not relevant to them as engineers (Flegg et al., 2012). These educational issues formed the backdrop to the development of a course in mathematical modelling and problem solving which is now being offered to second year engineering students at Chalmers University of Technology (Wedelin & Adawi, 2014).

Two renowned instructional approaches for dealing with these issues are problem-based learning and project-based learning (Mills & Treagust, 2003). A central feature of these instructional approaches is that an authentic problem “makes the starting point for the learning processes, places learning in context, and bases learning on the learner’s experience” (Kolmos, Graaff & Du, 2009; p. 11). An important difference is that project-based learning is more oriented towards the application of knowledge, whereas problem-based learning is more oriented towards the acquisition of knowledge (Mills & Treagust, 2003). Moreover, in project-based learning the goal is to produce a product or artefact (van Barneveld & Strobel, 2009). At the same time, these two approaches share and embody a number of principles that support learning – apart from situating learning in an authentic problem or activity – such as active- and collaborative learning, self-directed learning and interdisciplinary learning (Graaff & Kolmos, 2003), and PBL.
has become an acronym for both problem-based and project-based learning (Kolmos, Graaff & Du, 2009). It is worth noting that the form of PBL that is practiced in engineering education is often project-based, partly due to the hierarchical nature of engineering knowledge (Gavin, 2011).

However, the step from traditional teaching to learning to handle the complex real-world problems typically addressed in PBL is considerable. It may therefore be useful to establish a progression, where problem-solving skills are first explicitly addressed. Prince and Hoyt (2002), for example, noted that "the traditional undergraduate engineering curriculum is not designed to systematically develop relevant problem solving skills". They argue that "students should be introduced to relevant problem solving early in the curriculum and gradually encouraged and trained to adopt appropriate problem solving skills". Woods et al. (1997) found that having engineering students solve interesting and open-ended problems in small groups did little to develop their problem solving skills and confidence. On the other hand, they found that workshops focusing on problem solving skills enhanced the students’ skills and confidence. Woods (2014) argues that students should be skilled at problem solving before entering a PBL program, since PBL offers an opportunity to develop these skills but students do not develop problem-solving skills without “explicit interventions on the part of the teacher”.

The course in mathematical modelling and problem solving aims to improve real-world problem solving in science and technology, with a particular focus on the ability to use mathematics in such problem solving. The course specifically targets two important skills that are commonly overlooked in traditional teaching, because of its focus on explaining existing models and methods. Recognizing the ill-structured character and diversity of real-world problems and situations, the course therefore addresses mathematical modelling, which we see as an ability to see relevant (mathematical) aspects and create a mathematical description, acting as an important bridge from ill-structured real-world problems to conceptual representations and theory. Likewise, problem solving, in terms of an ability to explore and handle situations where no known or complete method is available, greatly extends the range of future problems that can be handled. Because of its mathematical character, the course is less tied to a specific subject than most courses in science and engineering. At the same time, the focus on mathematical modelling makes it natural to reach out to different areas of application, to a greater extent than most courses in mathematics.

The course is based on a set of reasonably realistic problems related to the application of mathematics in different fields, which are solved in a controlled setting intended to be especially suited for the learning and explicit teaching of problem solving. Together, the specific course objectives and the learning environment therefore provide a lower threshold for students who have little experience in handling more complex problems. In the following, we first describe some theoretical concepts and frameworks informing the design of the course. We then more closely discuss the motivation and philosophy of the course, the design of the problems and the learning environment. Finally, we discuss how this kind of course can serve as an intermediate step in a progression towards more self-directed PBL.

THEORETICAL CONCEPTS AND FRAMEWORKS
A key idea informing the design of the course is the notion of variation. A fundamental observation is that problems and situations occur in never-ending minor and major variations, and it is not possible to handle this diversity by learning a specific method for each problem. Rather, we may attempt to learn to handle future variation in new problems, by practicing to handle
variation with problems that we have today (Bowden & Marton, 1998). Here, we want to emphasize the distinction between well-structured and ill-structured problems (Jonassen, 2011). Well-structured problems are well-defined and self-contained, while ill-structured problems are formulated in an incomplete way, where the question is not precise, and where judgement and external contextual information are important for handling the problem. Well-structured problems are common in school situations and in abstract mathematical problem solving, while real-world problems are typically more ill-structured (Jonassen, 2011).

We also draw on a framework for mathematical thinking developed by Schoenfeld (1985; 1992). He argues that four aspects of mathematical thinking are necessary and sufficient for understanding why individuals are successful or not when engaging in mathematical problem solving: 1) resources – the individual’s mathematical knowledge base; 2) heuristics – the individual’s problem solving strategies; 3) self-regulation – the individual’s monitoring and controlling of thinking processes; and 4) beliefs – the individual’s “understandings and feelings that shape the ways that the individual conceptualizes and engages in mathematical behaviour”.

Another theoretical framework that is useful for our purposes is case-based reasoning (CBR), describing reasoning activities and learning in problem solving situations (Kolodner, 1993; Schank, 1982). CBR is based on the assumption that there is a “preference to reason using the most specific and most cohesive applicable knowledge available [...] and cases have both of these properties” (Kolodner et al., 1996). According to CBR, expert problem solvers “assess the current problem, find previous cases relevant to the current problem, leverage that case to inform a solution, assess the potential solution, and update internal memory as one learns from the experience” (Tawfik & Keene, 2013). Access to old cases or experiences is thus at the heart of the CBR cycle. Jonassen (2011) illustrates how practitioners across a range of disciplines, including engineering, to a large degree deal with ill-structured problems by reusing old cases relevant to the problem. Kolodner et al. (1996) argue that old cases “record what is possible, providing a reasoner with more probability of moving forward in a workable way than is provided by using general knowledge that is merely plausible”. (We note that the related term case-based learning does not seem to have a clear definition, and our focus here is primarily on case-based reasoning as a way to think when solving a problem.)

Finally, we draw on cognitive apprenticeship (Collins, Brown & Newman, 1989) to discuss the overall design of the learning environment. In traditional apprenticeship, the physical processes to be mastered are external and hence directly available for the students to observe. In order to apply apprenticeship methods to teach cognitive processes, these internal processes have to be made external, visible to the students, which is called modelling (not to be confused with the mathematical modelling as one of the course topics). One strategy to model the cognitive processes involved in problem solving is “think aloud modelling”, where teachers “describe what they are thinking and doing, why they are doing what they are doing, and verbalize their self-correction processes” (Duncan, 1996). The content that is taught and learned using a cognitive apprenticeship approach thus goes beyond domain knowledge (declarative knowledge such as facts, concepts and procedures of a subject) to include different types of strategic knowledge or “tacit” knowledge that experts draw on when solving problems. Collins, Brown and Newman (1989) describe three types of strategic knowledge: heuristic strategies or “tricks of the trade”, metacognitive strategies, and learning strategies. In cognitive apprenticeship, modelling and coaching are used together with teaching strategies that encourage students to articulate and reflect on their own thinking processes.
MOTIVATION AND PHILOSOPHY OF THE COURSE

The original starting point of the course was the observation that despite extensive traditional teaching, students have acquired a considerable amount of knowledge (in mathematics) that they are often not able to use. Why is this the case? There could of course be several reasons for this, including the possibility that the students simply haven’t understood the contents. This is often the outcome of approaches to teaching that do not actively engage students, do not demonstrate the relevance of the material, and do not address student misconceptions (Ramsden, 1992).

While acknowledging these well-known problems, we want to highlight another problem that we believe is fundamental. It is that students have generally been taught to solve well-defined problems by using given methods, i.e. by starting with knowledge that somehow just exists, and applying this to specific problems that fit perfectly with the theory presented; Wedelin et al. (2014) discuss how this can be observed in the present course. This has many consequences. One is that students know little about what real problems actually look like. They also know little about the early stages of solving such problems, which typically include modelling and related activities of observation, judgement and simplification, which are difficult to formalize. Instead, while teachers often tend to avoid the fuzziness of such problems and activities, problems given to students typically begin with an already given model (Zawojewski et al., 2008).

Another consequence is that students do not develop a balanced view on the relationship between knowledge and their own ability to think. When students encounter a problem they do not know how to solve, they give up too soon, assuming that more (existing) knowledge needs to be learned in order to solve this apparently new kind of problem. As this repeats itself, due to the diversity of problems, students’ ability to solve problems and their current knowledge always seems to be insufficient, leading to a constant lack of self-confidence.

The result is that students become followers, asking for solutions rather than thinking about problems and how to solve them. And in this sense they have in a way lost their own ability to think. In terms of Schoenfeld’s theory, this leads to a lack of control, and creates beliefs and attitudes that are unhelpful for constructive problem solving.

In the course, we therefore wish to help the students to regain the power of their own thinking in the following ways:

• Addressing mathematical modelling (in some areas of engineering). We provide a basic familiarity with an important and non-trivial class of realistic and ill-structured real-world problems, where we also consider the often neglected early stages of solving such problems. The modelling connects applications with the mathematics that the students already know; this is an example of a significant knowledge base that students thereby learn to effectively access and make use of.

• Making the students aware of the power of learning by exploration (as opposed to learning by reading a book or asking someone). This is an essential component in any real problem solving. It requires that you take control of and make the most of your own thinking, and that you believe that you with considerable effort may be able to find something interesting. Understanding an unknown problem or situation requires that it is investigated in an exploratory learning process which involves asking questions, looking at the problem from different points of view, deciding what is relevant, and so on. It further involves exploring different ways forward towards any goal. This leads to a deeper understanding, necessary to be able
to effectively use what you know in new situations, where existing knowledge is typically useful as a part in the whole. Only little new knowledge is required for this (depending on the problem domain).

• Giving students the insight about what is required to develop a problem solving ability also in other domains. This includes a similar understanding in terms of familiarity with many cases in a domain, relevant background knowledge, specific heuristics etc. Taking control of your thinking and associated constructive problem solving attitudes will be important in any domain.

DRAWING ON A LARGE SET OF STRUCTURALLY VARIED CASES
In order to learn and teach mathematical modelling and problem solving for real-world situations, a sufficiently large set of problems is needed, exhibiting a representative variation around the critical aspects that need to be covered (Bowden & Marton, 1998). However, in science and engineering, real-world problems often correspond to projects of considerable size. This means that, even for relatively small projects and entire educational programs, it is difficult to fit in an appropriate number of problems for students to experience the essential variation in critical aspects. Moreover, the problems will be time-wise apart, so it will be difficult to compare and discuss problems side by side. On the other hand, too small and possibly artificial problems may not serve well as models for real-world problems. It is also important that each problem is sufficiently large to be remembered as a case that can be referred to in the course and beyond. The students then build a case library of problems that they have solved themselves, to draw on during the course and in their future problem solving activities in the engineering workplace; see the previous discussion on case-based reasoning (Kolodner, 1993).

One of the key ideas when designing the course has therefore been to create simplified but still reasonably realistic problems (Wedelin & Adawi, 2015), so that a sufficient number of problems fit in a single course. This is somewhat facilitated by our focus on the use of mathematics, since mathematics is often embedded in other time-consuming activities of a project. We can therefore often demonstrate how mathematics can be used in real-world situations without actually doing a whole project.

When designing the problems, we have considered three critical aspects of being able to deal with real-world problems. The variation around these three critical aspects can be seen as spanning three dimensions of learning, see Figure 1. These dimensions, for which we also discuss our criteria in selecting and simplifying problems, are:

• Familiarity with real-world problems – a realistic problem and its solution (including any necessary derivation), acts as a representative case and contributes to a familiarity with real-world problems in the domain of interest. By realistic we here mean a problem that is meaningful to solve because its solution is of genuine interest, practically or theoretically. With this definition we include not only applied problems of immediate practical interest, but also problems related to steps in the formation and explanation of relevant theory or methods – such problems are useful to better understand theories, and also serve as examples of useful subproblems even if the end goal is to solve an applied problem. But we exclude artificial problems for which the sole meaning is to test if a given concept is understood or to practice some particular method, which is abundant especially in mathematics but also in other areas of science and
engineering. The challenge is then to keep the essence of the real-world problem: the simplified problem should still be a reasonably truthful model of some real problem that is actually out there, and any solution, its derivation, and its interpretation in the context should be similar.

- **Supporting knowledge** – the concepts and methods required to solve the problem (known in advance or created as a part of the solution process). Whether real-world problems require a lot of new knowledge to be learned clearly depends on the situation. We have here decided to avoid problems that require too much new theory to be learned, in order not to obscure our goal of developing the students’ own thinking and problem solving skills, and not to make them believe that the purpose of the course – and the way to become a better problem solver – is to learn more new theory (as in most other courses).

- **Processes and skills** – the particular way in which the solution (and its derivation) was found, and the modelling and problem solving techniques involved. This typically involves a search process where different considerations were made and different approaches were attempted until the suggested solution was found. In order to ensure that any simplification does not go so far that essential real-world characteristics are lost in this important respect, we have calibrated the problems so that they should not be easy to understand, and they should be challenging to solve. This, in other words, corresponds to the idea that the problems should be at least somewhat ill-structured, to invoke genuine modelling, problem solving, and the need to communicate.

It then also makes sense for the students and the teacher to discuss and reflect on the problems with respect to these three dimensions. This includes the specific context of the problems for each dimension, as well as what the problem as a representative example can convey about each dimension in general. We refer to this entire discussion and reflection as a **perspective**, and consider it to be an integrated part of the problem although it may not be a part of the problem statement. In the perspective we include relevant insights, attitudes, and expectations.

![Figure 1. Illustration of how several problems and their perspective span the three dimensions of learning, where each triangle represents one problem](image-url)
Turning to how to design the set of problems, the main issue is that the problems have to be carefully combined so that they together comprise a sufficient and representative variation in all three dimensions of our model. In other words, that the set will be useful to create familiarity with the real-world problem domain in question, to highlight the different kinds of knowledge required, and to develop basic problem solving skills for problems in this area. Exactly what it means to cover a dimension is difficult to formalize, in that it is a combination of many detailed conscious and intuitive considerations of what is useful to include. The global view also allows us to be pragmatic in the application of our general criteria for selecting problems, and if some problem or sub problem serves a sensible purpose in a bigger whole we do not hesitate to include it.

In total we have formulated about 30 problems broadly within the area of mathematical modelling, which we have grouped thematically after model type in six weekly modules. We here present three examples of problems from the course:

• Students are asked to find a good curve to fit a number of given points (time and distance). This is a problem given just in the beginning of the course. No prior instruction about curve fitting or the least squares method is given, and it is up to the students to come up with some way to approach the problem, determine what is a good fit etc. There is a very good answer to this problem, which is Kepler’s third law, but other solutions are equally accepted. The perspective of this problem includes the nature of different mathematical functions, curve fitting problems in general and where such problems arise (including a little history of science), different methods for curve fitting such as the least squares method, a reflection on what is “good enough”, and how it is natural to work with this problem in an iterative way, finding successively better models – essentially the so called *modelling cycle* (Borromeo Ferri, 2006), which the students through this problem discover for themselves.

• Students are given a description of a simple road network between two cities along a curved river, with certain given mathematical assumptions about how travel time on some roads changes with traffic intensity. We are concerned with the travel time between two cities, and the question is to what extent travel time could be reduced by building a bridge. An analysis includes thinking in terms of traffic flow and equilibrium, and requires assumptions about driver behaviour. It turns out that the bridge actually *increases* travel time; this is known as Braess’ paradox. The perspective of this problem includes how simple mathematical examples and models can highlight and explain unexpected phenomena which exist in reality but are difficult to see, Nash equilibria and its wider consequences, how flow and equilibrium are useful simplifying modelling concepts, how relevant assumptions can be made, and how you may fail if you are unable to find a precise mathematical formulation (in this case the criterion for the equilibrium). The problem involves both significant qualitative and quantitative thinking, but the actual calculation is almost trivial – so it is also an illustration of that more advanced math is not the way to solve this problem.

• The question is how you can determine the dosage, and time between doses of a drug. This involves understanding the problem both quantitatively and qualitatively, deciding what is relevant, making considerable simplifying assumptions, suggesting what you need to know etc. A key step is to model how the concentration of the drug in the blood varies with time. The problem can be solved in several ways, from very complicated and exact to very simple
but with unrealistic dangerous consequences. The perspective here includes the considerable
modelling simplifications that are possible by thinking about the context and using common
sense knowledge, without knowing very much about the specific problem, and the importance
of a qualitative understanding of the quantitative behaviour both of reality and any models.
In the problem solving, it is about how you can easily get stuck in a complicated mess, about
clearly structuring your problem solving in suitable steps, starting with something simple,
being careful and drawing the full logical consequences of your own assumptions, and see the
many detailed ways - easy and complicated - in which the problem can be solved.

For a more detailed formulation of these problems, and more problems, see Wedelin (2015).

TEACHING PROBLEM SOLVING IN A COGNITIVE APPRENTICESHIP
ENVIRONMENT
The learning environment that we have designed for the course, of which the problems constitute
a key element, can be characterized as a cognitive apprenticeship environment (Collins, Brown &
Newman, 1989) where students practice solving reasonably realistic problems where no specific
method to solve them has been explained, and where the teachers actively in lectures and in
supervision attempt to share their experiences and insights in modelling and problem solving.
This also encourages attitudes and work practices similar to those of people who have experience
in handling real-world problems.

Students work in groups of two, to ensure that everyone is actively engaged in the problem
solving, and to enable communication as an important aspect of the problem solving process.

Every weekly module – six in total – begins with an introductory lecture introducing the
theme for the week, however without explaining how to solve the problems. After each week
there is a follow-up lecture presenting the solutions of the teacher, common difficulties and
alternative approaches, and a perspective on the problems solved and beyond. The course ends
with a reflective report.

The course is well-structured in the sense that students start working from the first day and
roughly know what they are expected to do every week, and with many problems and weekly
modules there is a sense of continuous progress. The course offers a controlled environment also
for the teachers, since the relatively small problems can be supervised in a reasonably predictable
way, and useful supervision guidelines can be written to help new course assistants.

Extensive opportunities for supervision are provided, where the limited size of the problems
enables practice and feedback on the whole problem solving process many times during the
course. The challenging nature of the problems makes communication within the group and
with the teacher necessary. Teachers give Socratic supervision – asking questions rather than
giving answers – and in context give general advice about how to solve problems. The problems
in combination with this kind of supervision turn out to be efficient in identifying individual
student difficulties, and make it relatively easy to give appropriate feedback (since these smaller
problems in this controlled and predictable setting are relatively easy to learn to supervise).

There is a strong emphasis on the process of solving problems, rather than on solving problems
“correctly”, or to a given level (it is not always clear what the “best” solution is for modelling
problems). Failure is seen as normal, and a learning opportunity. Instead, everyone is encoura-
ged and expected to do their best. As a consequence, assessment is pushed to the background,
and students are confident that if they work hard they will pass. We promote the adoption of
constructive problem solving attitudes, including patience, self-awareness and that the students should trust their own thinking, so that students grow into the role of being a problem solver.

Throughout the course we encourage reflection, and in particular what students can learn by comparing what they did themselves with the solutions suggested in the follow-up lecture. We try to exploit the variation in the problems by discussing relevant differences and similarities across problems. We also use the perspective to add to the students’ own experiences by pointing to relevant higher order issues in modelling and problem solving, including highlighting important classes of problems, and general ways to think and talk about modelling and problem solving. This means that the role of the teacher is not only to have subject knowledge or know how to solve problems, but also to talk about the problem solving process, and raise awareness about key issues. There is no magic in this, but more of an ambition of the teacher to share his experience to reach beyond the individual problems that the students have worked with.

For a more detailed description of the design of the learning environment, see Wedelin and Adawi (2014).

**DISCUSSION**

The course shares with PBL the idea of inquiry-based learning, and the ambition that students through this kind of instruction should learn to solve unknown real-world problems. However, the course is also quite different in its use of *many smaller problems rather than a few big ones*. This, by itself, creates a natural step in a progression. It also enables a more continuous variation in all aspects of the problems, and therefore an increased opportunity to see patterns, especially in the problem solving process. We can then be more active in helping the students to see such patterns, and explicitly teach problem solving based on this variation. Scaffolding is considered very important in PBL, but is mostly focused on solving the problem given to the students, rather than teaching problem solving. At least this does not come automatically from how PBL is commonly described.

We note that if PBL is applied to domains where the practice naturally consists of many cases, no major effort may be required to make problems or cases smaller. However, PBL is not explicitly based on learning to handle diversity by variation, which is important for problem solving in any domain. A lack of diversity in PBL has been observed in the phenomenon that subject coverage becomes more difficult to achieve compared to traditional teaching. However, given the model in Figure 1, it appears that the same difficulty could also apply to the other dimensions of learning. So it is important to remember that a pattern can only appear when you are provided with several examples. And it is only possible to make the necessary judgements if you are familiar with the problem domain, in terms of the diversity in problems previously encountered and solved.

Then, while students have to solve problems, without knowing in advance how to solve them, *we otherwise try to reduce the complexity* around this challenge. And given our students’ lack of experience in basic problem solving this is already a major step compared to working with given methods. The students do not need to take major control of planning of activities or their own learning, before they are used to take control of their thinking, and have a balanced view between the trade-off between learning by thinking, and learning by studying. However, they do have to keep track of how they spend their time, which is important in all problem solving. The smaller problems facilitate a well-structured course, make small two-person groups natural, and simplify effective feedback and supervision. Finally, learning new traditional knowledge in terms...
of conventional theory is not a significant part of the course, and would be counterproductive in our desire to change students’ beliefs about what you need to solve problems. It is also quite unnecessary, since our students already have a large body of knowledge in mathematics, and we find it natural to make sure that the ability to use what you know should have a priority over acquiring new knowledge.

Turning again to PBL, we find that PBL addresses a more ambitious goal that should come later. Of course, mature students and professionals should be able to handle the full complexity of large real-world problems, but if a fundamental and identifiable gap in students’ abilities can be observed, it makes sense to target this specifically. When students know how to take control of their thinking, and have a balanced view between learning by thinking and learning by studying, it makes sense to continue to more ambitious tasks.

CONCLUSIONS AND FINAL REMARKS
In this paper we have described the design of a course in mathematical modelling and problem solving for engineering students. The course aims to prepare students for handling unknown future problems and situations to a greater extent than traditional courses. Both the modelling aspect and the problem solving aspect of the course contributes to this. This also requires some significant unlearning, caused by prior ways of teaching, where we note that a key missing component in students’ ability to solve problems is learning by exploration. The focus on modelling problems further addresses the early stages of real-world problem solving, which is likewise neglected in traditional engineering education. Another effect of the course is that modelling and problem solving become real topics for students, the level of abstraction is raised, and a more process-oriented view is developed.

A particular feature of the course is the relatively large set of problems, which creates an opportunity for the students to experience a range of problems that in the case of full size problems would take a very long time to accumulate. This is therefore a complementary experience to what PBL typically offers, at least in some areas. Furthermore, the problems give the teacher an opportunity to convey her experiences related to the variation across problems, which cannot be naturally conveyed if only a few large problems are considered.

The learning objectives have been carefully chosen, and the learning environment has been designed uncompromisingly based on these. Our experience with the course shows that these objectives are indeed very important for students who have been raised in a traditional learning environment. We also see that the students are able to adapt and relearn very quickly in the right environment (Wedelin et al., 2014). Problem solving abilities, including student beliefs and attitudes, are significantly developed within the scope of a single course, and students adopt a problem solving mindset. The response from the students is exceptionally positive. Many students say that they have developed a new way to think. We receive comments like “we have been able to solve problems that we thought we would never be able to solve”, and “Can you really learn problem solving, learn to see patterns? In my own experience with this course, yes. It is not a talent, it is a way to think that you can learn”.

Clearly, the need for this kind of teaching depends on what the rest of the curriculum looks like. For students with a background in traditional engineering courses it is very important. In a program dominated by a PBL method of instruction, the course provides a progression, with a more constrained mode of teaching, and by requiring little in terms of new theory. It also provides concepts and a language for talking about modelling and problem solving. It is also
The course itself can be of interest for a wide range of educational programs. Mathematics is one of the few significant bodies of knowledge that students in many different programs have. There is therefore a certain generality to this teaching, and with some adaptations in the selection of problems, a similar course can be given to students in many different programs.

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Is PBL really a better way to teach and learn?

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Most education leaders or developers implementing problem-based learning have probably heard the question, “Is PBL really better than other ways to teach and learn?” We, the authors, have had reasons to try to answer this question during our long experience of PBL. We have identified five areas that should be considered before an answer can be provided and we have used theory and research to shed light on these areas.

The first area is a changing society where students and employers expect universities to meet new challenges. Knowledge about cognition and evidence concerning what matters in educational practice have shown that PBL offers opportunities to apply several of the most important principles that result in better learning.

Comparisons of PBL-curricula and “traditional” curricula initially yielded limited results, but with growing insight into the effects of bias in comparisons it has been shown that a well-implemented PBL-curriculum does result in better outcomes beyond improvement of knowledge. We believe that we can answer the question with a “yes”, provided that PBL is implemented in a way that takes into account knowledge of what matters for learning.

Key words: Problem-based learning, small group learning, cognition, learning outcomes

INTRODUCTION

Most probably, everybody practicing or advocating problem-based learning (PBL) has been asked many times whether PBL really is a better way to teach and learn. We, the authors of this reflection, each have 25 years of experience of tutoring in PBL contexts and some ten years of experience of educating and training tutors for PBL within faculty staff development programs in medicine, biomedicine, and health care education. We also have long time personal experience of practicing as well as educating and training others for various other teaching formats, and we have noticed that similar questions are rarely asked in those contexts. Why is the effect of PBL on the outcome asked for whereas the effect of other learning or teaching formats is not? PBL can be categorized as a small group study format supporting self-directed learning (Barrows & Tamblyn, 1980; Schmidt, 1983). Students start by investigating a case or a situation in order to be able to explain the situation or to propose an educated choice of action that could be undertaken. They do so prior to having all the knowledge and higher order cognitive skills. The students themselves define the questions or study goals they need to address in order to be able to proceed, and these questions, which often relate to several subject areas, are the basis for their studies. After self-study the students meet again and discuss their findings in relation to the case. The tutor is supposed to adopt the role of a facilitator in the first place and not of a provider of information. All this is a reversal of the long standing paradigm in the history of higher education meaning knowledge before application (if any application at all!). The defini-
tion of a teacher working within that paradigm is someone who openly demonstrates his or her superior knowledge in order to help students to learn, often assuming a process of knowledge transfer. It is perhaps not surprising that a teacher who has become used to being a “sage on the stage” finds it difficult to adapt to the role of a “guide on the side”, and thus wonders if it really is possible to “cover” all subject matter within the format of PBL.

Depending on how they are applied, other teaching and learning formats such as, e.g., the Harvard Business School case method and laboratory work may also often be characterized as formats supporting self-directed learning, but they are not always perceived that way. To our understanding from many discussions, the probable explanation is that such formats offer more room for teacher control. Consequently, the perceived lack of teacher control may be an important reason why the claimed merits of PBL are questioned so often.

With a history of almost fifty years, PBL has become an accepted tool among other tools for teaching and learning (Kinkade, 2005). However, despite that PBL has been used worldwide for several decades and in spite of a wealth of literature concerned with PBL, the question phrased in the title still seems to await a final answer as judged by our experience from many courses with medical teachers. In this paper we will share with you how we ourselves have approached the answer to the question using literature in the field of learning in general and PBL in particular. We present a selection of literature related to five areas that have to be taken into account in order to be able to answer the question according to our experience. These areas are: (1) demands on higher education caused by changes in the society; (2) the increasing knowledge about cognition from various disciplines; (3) results from studies of what really matters in educational practice; (4) comparisons of learning results of PBL-curricula with those of more traditionally taught curricula; (5) the importance of taking bias into account when making such comparisons. Thus, this is not a systematic review of the vast literature about PBL (by the end of October 2014, a search for “problem-based learning” resulted in more than 6,000 hits in PubMed and more than 160,000 hits in Google Scholar).

A changing society
One possible approach to deal with the question in the title used by Egidius (1999a, 1999b) is to put PBL in a broad and societal perspective to try to understand why it is being used rather than to debate the claimed or missing merits of PBL. The content under this heading is inspired by the texts by Egidius (1999a, 1999b).

During the nineteen sixties some fierce riots were orchestrated by students at Berkeley, California, in Paris and elsewhere in the western world societies. The students protested against the power of the professors and authoritarian one-sided lecturing. Teaching at universities was criticized for not allowing critical discussions about society. Research and higher education were accused of being isolated from society. The student protesters demanded democracy and to be given a voice. They wanted discussions, small group studies, and the freedom to decide what they considered interesting and important. To them the lectures were the very symbol of the authoritarian hierarchical system at universities.

Outside the world of higher education the detailed governance of production lines in industry was abandoned and the employees, individually or in groups, were given responsibility for their tasks instead of instructions. Employees turned into collaborators who networked and worked in teams. This called for skills in communication, collaboration and the ability to direct one’s own work, skills that were not trained in the traditional schools and universities at the time.
Also in the nineteen sixties, protests developed against bureaucracy and the ruling by the letter of the law within the large governmental administrations. In the nineteen eighties and nineties, bureaucracy and governance by rules had to yield to governance by goals and expected outcomes. This development within society called for people who could search for and find facts, for critical appraisal, for reflection on problems, for a scientific approach, and for the ability to predict the consequences of alternate decisions. On the whole these are skills that are developed within PBL. At the new institutions for higher education, problems were not used for the application of prior knowledge but, rather, the educational programs were based on problems. PBL was a choice in opposition to the traditional pedagogy in higher education. Lectures were avoided and the education was student-centered and based on authenticity. Students became able to influence the direction and content of their studies, and skills needed in society were developed.

“Consequently, asking if PBL is effective is not a relevant question. You do not choose PBL for its effectiveness. Maybe, it is not at all effective or it is not at all good at preparing the students for their future professional careers. In the perspective of the upheavals of the nineteen sixties and seventies the choice of PBL is an ethical question. The students are given the responsibility just as the responsibility for accomplishing something is given to us as individuals in a flexible and changing professional life. This is in accordance with the principles of self-directed learning.” (Egidius 1999b, p 48). At the entrance of the twenty-first century, PBL has become accepted as a way of learning that agrees with the view of our time on the human being as someone who is able to take responsibility for his or her own life, learning, and professional work.

Knowledge about cognition

Today more is known about conditions of importance for learning than was known when PBL was developed. Cognitive psychology has developed, and recently findings in neurobiology regarding learning have been compared to those in cognitive psychology and the conclusions are the same. In this section we are looking at PBL in the light of these findings.

Early in the development of and research on PBL, Schmidt (1983), then at the University of Maastricht, identified three important learning principles in cognitive psychology of relevance for PBL. In 1993 Schmidt returned to these principles and presented further support for them (Schmidt, 1993).

The first principle is activation of prior knowledge. Students’ knowledge from previous studies has always been seen as important, but according to this principle prior knowledge has to be activated before further study in order to facilitate the processing of new information. When students have the first PBL session with a case/problem, they will try to analyze and understand the problem using their prior knowledge, which is thus activated. During the session the students identify where their prior knowledge is insufficient and this lack of knowledge forms the basis for the study goals they agree upon for their self-study.

The second principle concerns the importance of context. It is easier for students to apply knowledge further on in life if the situation for application resembles the situation where learning took place. This encoding specificity means that retrieval cues are stored with the information and it can be achieved with PBL by selecting cases/problems that are contextualized so as to resemble situations where knowledge needs to be retrieved. This is both a matter of how knowledge is structured in memory and of the importance of cues for availability of the stored memory. Students use their study goals for self-study and their learning is thus connected to the case, which creates opportunities for structure and cues related to the case.
The third principle is elaboration. Elaboration can be achieved by students explaining to each other, asking and answering questions, writing or presenting summaries etc. Students’ understanding and retention of knowledge is increased by elaboration. This occurs when students in PBL meet for the second time, after self-study, and discuss their new understanding of the case/problem. The students then explain to each other what they learned during self-study, they compare findings and ask each other questions to able to clarify ambiguities. It is an advantage if they also draw and write on a board during this phase.

Motivation increases the time students spend on self-study and is thus also important for learning (Schmidt, Rotgans & Yew, 2011). The use of cases relevant for the future profession tends to increase students’ motivation. The properties of the cases/problems are important since these have to be designed so that students know and understand enough to be able to engage in a discussion that activates prior knowledge. They should also be challenging, engaging and relevant to future practice, both to increase motivation and to make stored memory more easily available through cues.

An important conclusion of these principles is that when students meet in groups, the most critical event from the point of view of cognitive psychology is a discussion in an open climate with the participation of all the students in the group. It is important for a thorough activation of prior knowledge, for identification of lack of knowledge and for elaboration. The tutor has an important role in contributing to the open climate, in stimulating elaboration and in scaffolding learning.

A fourth principle was added by Gijselaers (1996), namely the importance of meta-cognitive skills. This means that students are able to self-monitor their learning including the setting and evaluation of goals, and selection of strategies. Meta-cognitive skills can be learned and there are opportunities to do so in PBL if students and their tutor engage in reflection and evaluation after group sessions. These practices probably depend on the skills of the tutor, since students will have to be well acquainted with group work to initiate evaluation themselves.

There is now further evidence in support of the principles mentioned above (Schmidt, Rotgans & Yew, 2011). This evidence supports the importance of activation of prior knowledge and opportunities for elaboration for students’ motivation, comprehension and long-term memory. The scaffolding provided by tutors in the PBL setting has been found to be more effective than e.g questions added to problems. Both collaboration in groups and self-study are important and stimulate students’ regular study and thus decrease the risk of failure and drop-out.

Yew, Chng & Schmidt (2011) found that learning in the different steps of PBL was cumulative and students’ prior knowledge influenced their learning as well as their achievement in the final test. The finding that learning was cumulative means that learning in one step depends on learning in the previous one, and that all steps are important for the final result, again stressing the importance of all phases of PBL (the steps being, activation of prior knowledge, self-study and elaboration after self-study).

Evidence for a positive impact of the tutor’s social congruence on students’ learning in all the different phases of PBL has been presented (Chng, Yew & Schmidt, 2011). The tutor’s cognitive and social congruence as well as subject matter expertise influenced students’ test achievement. The tutor thus has an important role for the achievement of students in PBL. The influence of the tutor has been found to be stronger on academically average students than on academically strong or weak students (Chng, Yew & Schmidt, 2014) and this is important since most students are average performers.
In a recent review, Friedlander et al. (2011) presented how findings from neurobiology can be applied to teaching and learning. They identified ten aspects of which some are directly applicable to PBL. Repetition is important for increased retention. With well-designed and sequenced cases/problems in PBL, repetition occurs when students use prior knowledge in their first group meeting. It is also easy for a skilled tutor in PBL to facilitate return to concepts from previous sessions. Reward and reinforcement are positive for learning and this can be achieved, e.g., by passing exams. Students who find increased understanding rewarding may have a better chance of study success. A well-functioning PBL-group may increase the joy of understanding as well as giving confirmation of achievement. Active engagement by students enhances learning and this is one of the key features of both group sessions of PBL. Stress is largely negative for learning. However, mild stress has been found to have positive effects. Learning in small groups as in PBL can at best create the kind of mild stress that is positive for learning.

**What matters in educational practice**

In his monograph on innovations in schools that have had effects on student accomplishments, Hattie (2009) summarized studies of more than 800 meta-analyses dealing with this topic. The meta-analyses represent 52,657 original studies and 146,142 effect sizes. An effect size is the difference between the means of two distributions expressed as the number of standard deviations. It was calculated by dividing the difference between the means by the size of the pooled standard deviation for the two distributions. In all, 138 innovative influences were ranked. Among influences that scored an effect size above 0.4, the mean effect size of all effect sizes studied, 31 were categorized as “teacher” and “teaching”, two of the six domains studied. At least twelve influences are actions that easily take place or could take place in small group teaching in the format of PBL and several of them are found among the most highly ranked influences. The most effective influence within these two domains is feedback to teachers (Table 1) and this is also one of the top influences of all the ranked influences. Some other examples are reciprocal teaching – each student takes a turn at being the teacher and practices summarizing, questioning, clarification, and prediction in a supportive dialogue with the teacher; feedback to the student from various sources; teacher-student relationships; spaced vs mass practice – increasing the number of deliberative practice opportunities rather than the time on task; meta-cognitive strategies; and, finally, self-verbalization/self-questioning by students (Table 1).

**Table 1. Innovations that have been found to have a strong influence on student accomplishments (Hattie, 2009), and that can easily be applied in problem-based learning.**

<table>
<thead>
<tr>
<th>Influence on student accomplishments</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback to teachers</td>
<td>0.90</td>
</tr>
<tr>
<td>Reciprocal teaching</td>
<td>0.74</td>
</tr>
<tr>
<td>Feedback</td>
<td>0.73</td>
</tr>
<tr>
<td>Teacher-student relationships</td>
<td>0.72</td>
</tr>
<tr>
<td>Spaced vs mass practice</td>
<td>0.71</td>
</tr>
<tr>
<td>Meta-cognitive strategies</td>
<td>0.69</td>
</tr>
<tr>
<td>Self-verbalization/self-questioning</td>
<td>0.64</td>
</tr>
</tbody>
</table>
Comparisons of PBL-curricula and “traditional” curricula

After the implementation of PBL several attempts were made to identify improvements from applying PBL, but small or no differences were reported (e.g., Albanese & Mitchell, 1993; Vernon & Blake, 1993; Colliver, 2000). Hattie (2009) synthesized the results of eight meta-analyses comprising 285 studies concerned with the effects of PBL on student accomplishments and found the effect size to be negligible (0.15), although the standard error of the effect sizes was large. Advocates of PBL, such as us, have often been surprised by this poor evidence for the effect of PBL on learning in the literature. The scarcity of evidence is in such contrast to the impression we get as tutors from the quality of discussions in functional PBL groups.

The nature and assessment of student accomplishment have to be looked into and understood to allow for sound conclusions regarding the effects. Hattie (2009) reports about the effect sizes on the acquisition of factual knowledge in PBL from five of the eight meta-analyses as being zero or negative as compared to traditional instructional methods. However, two of these meta-analyses exhibited very positive effect sizes, indeed, for application of knowledge (0.4), understanding principles (0.75), and skills like recall of knowledge (0.66). One meta-analysis also reported positive effect sizes for self-directed learning (0.54) and attitude toward learning (0.52).

Koh, Khoo, Wong & Koh (2008) published a review that gives support to the suspicion that one should look beyond factual knowledge achieved to find evidence of further merits of PBL. The review is based on 13 studies that met all their inclusion criteria. The studies report assessments of professional competencies among physicians whose professional experience ranged from first-year residency to 20 years of medical practice and who had graduated from medical schools applying PBL during the first two years of the curriculum or throughout the whole program. The selected studies also included control groups of graduates from medical schools adopting traditional curricula. The evidence in favor of PBL presented in the review was strong for both self-assessed and observed competencies regarding coping with uncertainty, appreciation of legal and ethical aspects of health and moderate for self-directed continuing learning. Furthermore, the evidence was strong for the observed competencies diagnostic skills or accuracy, communication skills, appreciation of cultural aspects of health care, responsibility, and self or peer appraisal. Interestingly, judging by the self-assessments there was strong evidence of lack of medical knowledge but this was not supported by the evidence from the objective assessments (cf. Peters, Greenberger-Rosovsky, Crowder, Block & Moore, 2000).

Using a database of 9,000 students, van den Berg and Hofman (2005) reported results from a study of the impact of student and faculty factors on study progress at universities in the Netherlands. Among several factors showing an impact on student success, PBL was found to have a positive effect. They discussed that the interaction between students and between students and teachers become more intense in a PBL curriculum. In particular, such interactions could be helpful to students who would otherwise become isolated in a traditional academic curriculum, like those from ethnic minorities, according to van den Berg and Hofman (2005).

As a proof of the importance of the findings and conclusions by Koh et al. (2008), Norman from McMaster University, the birthplace of PBL, who is known for his skepticism of the common practice in education to apply pedagogical innovations without referring to evidence, wrote a commentary in the same issue of the journal as Koh et al. (2008) with the title “PBL makes a difference. But why?” (Norman, 2008). He had become convinced that there is evidence in support of PBL but now there is a need to know why the method works to be able to guide those who want to implement it.
The effects of bias in comparisons

It is likely that comparisons between different curricula are biased by other differences than the intervention. It is obviously not possible to carry out blinded interventions in educational contexts. However, it is also almost impossible to perform correctly designed studies comparing an intervention group to a control group since students are not likely to let themselves be randomized to different groups in a study.

Medical schools in the Netherlands lend themselves well to curriculum comparisons since the students are randomized between the eight (as of 2012) medical schools, all state-based, according to a lottery-based admission procedure regardless of their medical school preferences.

In 1974, the Maastricht medical school enrolled their first students with a PBL curriculum from the start. Over the years, many comparative studies involving the Maastricht medical school have been performed and some of them have presented comparisons of how knowledge and skills differ among students from different schools and effect sizes for differences have been calculated. These have recently been presented in a review (Schmidt, Van der Molen, Te Winkel & Wijnen, 2009, Table 2). This study showed high impact on students’ content with their studies, on clinical and communication skills as well as on progress through studies. The effects on knowledge and clinical reasoning, however, were found to be almost negligible.

Table 2. Comparisons of results in different domains by students from on the one hand "traditional" medical schools and on the other the problem-based medical school in Maastricht (Schmidt et al. 2009).

<table>
<thead>
<tr>
<th>Domain</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge acquisition</td>
<td>0.07</td>
</tr>
<tr>
<td>Diagnostic reasoning</td>
<td>0.11</td>
</tr>
<tr>
<td>Communication</td>
<td>1.46</td>
</tr>
<tr>
<td>Medical skills</td>
<td>0.83</td>
</tr>
<tr>
<td>Content with experience of school</td>
<td>0.66</td>
</tr>
<tr>
<td>Graduation rate</td>
<td>0.33</td>
</tr>
<tr>
<td>Study duration</td>
<td>-0.68</td>
</tr>
</tbody>
</table>

There are several kinds of bias that can affect such curriculum comparisons and, according to Schmidt, Muijtjens, Van der Vleuten & Norman (2012), only some of the bias was controlled for in the previous studies (e.g. Albanese & Mitchell, 1993; Vernon & Blake, 1993; Colliver, 2000; Koh et al., 2008). According to these authors (Schmidt et al. 2012) the following aspects of bias should be considered as well:

**Differential enrollment:** it has been shown that the entry qualifications of the students have a strong impact on their knowledge acquisition in medical school (Hecker & Violato, 2008). In several of the studies mentioned above (Albanese & Mitchell, 1993; Vernon & Blake, 1993; Colliver, 2000), this factor has not been controlled for. In the studies from the Netherlands this has been controlled for due to the lottery procedure.

**Differential sampling:** If students in curriculum studies are sampled in different ways this may affect the results. E.g., students who volunteer for studies tend to belong to the group of the best performing students. If they are compared to a group that includes all students the results may not be correct. This has often not been controlled for in previous studies except in the ones from the Netherlands.
Differential attrition: If more students graduate in one school than in another, it is reasonable to assume that it is not the best performing students that drop out but rather the opposite. The results from the school that has more drop outs would thus gradually become better. This has not been controlled for in any previous study.

Differential exposure: If poorly performing students do not drop out they may instead spend more time studying and improve the results of the school. This has not been controlled for in any previous study.

We want to add a fifth bias. Based on Hattie (2009) and the experience of ourselves and others we conclude that it is important to consider how PBL has been implemented in a curriculum. PBL can be implemented in so many different ways (Kinkade, 2005) that what you may actually compare are differences in the way PBL has been implemented. The Maastricht medical school introduced PBL early and their curriculum has been the subject of research since then. Thus, we know how PBL has been implemented and the results are not biased by other forms of implementation in other schools.

Schmidt et al. (2012) recalculated the data taking all bias in some of the previous studies into consideration and found increased effect sizes in the domains where effect sizes were previously shown to be negligible (Table 3).

Table 3. Differences in results in the cognitive domain by students from on the one hand “traditional” medical schools and on the other the problem-based medical school in Maastricht. Results are presented before and after correction for differential attrition and exposure (Schmidt et al., 2012).

<table>
<thead>
<tr>
<th>Domain</th>
<th>Effect size before correction for bias</th>
<th>Effect size after correction for bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge acquisition</td>
<td>0.02</td>
<td>0.31</td>
</tr>
<tr>
<td>Diagnostic reasoning</td>
<td>0.07</td>
<td>0.31</td>
</tr>
</tbody>
</table>

DISCUSSION
After this study of the literature, we believe that we can answer the question “Is PBL really a better way to teach and learn?” with a “yes”. We also believe that an answer is emerging to the question “PBL makes a difference. But why?” posed by Norman (2008).

The characteristics of PBL according to our view should be the engagement of students in a discussion about something that has to be explained or solved. This discussion depends on evoking some specific cognitive processes like, i.e., activation of prior knowledge. The discussion should include the verification/falsification of student generated hypotheses. This calls for discussions between students in an open climate. PBL assumes the presentation of something to be discussed by everybody in a group and it is a procedure that scaffolds the discussions. Attention to group dynamics is also an important aspect.

We hope that it is clear from this article that “better” implies competencies that advance beyond merely gaining factual knowledge for a test. When discussing PBL it is probably also important to remember that PBL curricula often put emphasis on communication, attitudes and training of practical skills which may contribute to the results.

So why do we say that PBL is “better”? Because evidence from cognitive psychology, neurobiology and results from correctly designed comparative studies support our conclusion.
Hattie (2009) has identified what matters from his synthesis of meta-analyses based on studies of real world pedagogical innovations and their effects. Many of the identified influences can be subject to teacher control and are particularly applicable for small groups of students, be it within PBL groups or not. At the very heart of these influences is bi-directional feedback, respect, meta-cognitive awareness and self-articulation. The evidence presented by Hattie (2009) gains further support from theories of cognitive psychology. The principles from cognitive psychology presented by Schmidt (1983, 1993), Gijbelsaers (1996) and Schmidt, Rogan & Yew (2011) are probably more easily adopted in PBL than in other less formalized small group teaching formats. And, finally, the studies from the Netherlands have shown that the outcomes from a PBL-school were better than the ones from more traditional schools. The improvements of factual knowledge were, however, not as impressive as those of other competencies.

The emerging answer to Norman’s question “why” is that PBL provides a scaffold to case-based small group work, as supported by the evidence presented above.

Norman (2008) also comments on the fact that PBL, once it was implemented at McMaster University, “caught on like fire” and spread all over the world despite the lack of convincing evidence for its effectiveness. Probably, PBL has often been implemented because of the reasons presented by Egidius (1999a,1999b). The introduction of PBL has been a logical consequence of currents of change in modern society to the extent that, to many early adopters, the alternatives have almost been unthinkable.

Maybe we should consider ourselves lucky that medical education leaders and teachers did not ask for evidence at the time. The early studies, where there were no convincing effects of PBL, all focused on factual knowledge, since the outcome measure was usually standardized knowledge tests. Medical schools were included in most studies, partly because they were the main adopters of PBL and perhaps also because the national tests in North America could be used for comparisons. Students’ entry qualifications have an impact on the outcome of their studies (Hecker & Violato, 2008). When entry qualifications were corrected for, the difference between medical schools with different curricula was small, i.e. the individual differences between students’ entry qualifications explained most of the variance (Hecker & Violato, 2008). Their study was performed with data from medical schools in the USA where national entry qualification tests as well as national exams can be used. In the USA and in most of Western Europe medical schools attract many students and high grades are needed to enter. These students have adopted strategies to cope with understanding and learning what is demanded by them. It is thus likely that curricular reforms will have limited effect on students who will graduate to a large extent irrespective of educational policies. Results from students with lower school grades might improve more (cf. Van den Berg & Hofman, 2005). Still, as we have seen above, substantial improvements have been shown from medical schools that have adopted PBL (Schmidt et al., 2012). Also, the average medical student gains from PBL (Chng et al., 2014).

However, the implementation of PBL requires careful planning. It has been shown that the quality of the cases and the competences of the tutors are the most important factors for the small-group learning in PBL curricula (Schmidt & Moust, 2000). Cases have to be designed so that the students will reach the intended learning outcomes and so that the level is well adapted to the knowledge and understanding of the students. Tutors need to learn how to best facilitate the processes in PBL. For both the development of cases and tutors, a support organization for faculty development is needed.
After having presented the arguments from the literature supporting the application of PBL for teaching and learning, we must also bear in mind that calling a learning activity PBL is not what matters for the outcome. It is the understanding and application of some critical learning principles that matter. These principles can easily be included in the PBL practice but also to some extent in lectures, group work and other forms of case based studies. What matters for learning is what students do, not what you call their activities!

ACKNOWLEDGEMENT
We thank all our students and PBL course participants who have challenged us and questioned PBL, thus prompting us to reflect on our practice and to seek evidence.

We are grateful to Henry Egidius – his wide knowledge, curiosity and enthusiasm have inspired us ever since we approached PBL for the first time.

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Courses for tutors in problem-based learning. Current challenges at four Swedish universities

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The key role of the tutor in problem-based learning (PBL) is to help students become self-regulated learners. Tutors need training to acquire the necessary facilitating skills for this task. The aim of this article is to describe and discuss how PBL tutor training is currently arranged at four universities in Sweden: Linköping University, Lund Medical Faculty, Uppsala Medical School and Örebro School of Medicine. Moreover, we seek to analyse how the content and format of the tutor training courses correspond to the desired skills and competencies for PBL tutors described in the literature. We draw especially on work coming out of three pioneering universities for PBL: McMaster University, Canada; Maastricht University, The Netherlands; and Linköping University, Sweden. One aim has been to construct a framework for analysis that uses categories specifying the knowledge base, capabilities and skills to support students’ learning processes which characterise the full-fledged PBL tutor. For this framework, we have used the following categories: Knowledge of PBL and pedagogical theories, Personal traits, Student-centeredness, Ability to handle group processes, and Subject knowledge. We collected descriptions of the course design and content from the four universities, and assessed to what extent these categories were represented within the courses. Our results show that all categories inform the course content at all four universities, though the design varies between courses. In summary, we show that the four PBL tutor training courses are all designed to enable participants to experience PBL first-hand both as members of a tutorial group and as tutors. They all also include a theoretical base and offer opportunities for discussion and reflection with peers; however, there are some differences in design between the courses. According to participants, all four courses provide good preparation for the tutor role. Yet, we see a need for the programmes to organise continuous educational support for tutors after they have started their work with groups of students.

Key words: Courses for tutors in PBL, Educational Development, Problem-based Learning, Learning by doing, Reflection

INTRODUCTION

The authors of this article all have extensive experience of arranging courses for tutors in problem-based learning (PBL). We know each other from the Swedish PBL network, and have there identified a need to discuss if and how our courses meet participants’ needs for preparation for their...
task as tutors. We believe that such a discussion can be of interest for others who are running or developing similar courses or other teacher training programmes within higher education. In Sweden, the Faculty of Health Sciences in Linköping pioneered by introducing PBL for all health professional study programmes in the 1980s. Since then, PBL has been implemented to varying degrees within, for instance, psychology, environmental science and engineering teaching at Linköping University. During the 1990s, the Medical Faculties in Lund (speech therapy, physiotherapy, medicine and later audiology, occupational therapy and biomedicine) and Uppsala (mainly medicine and nursing) introduced PBL in their curricula. In Uppsala, PBL groups in medicine were first limited to the sixth and seventh semesters (internal medicine) out of eleven, but used throughout the curriculum from 2006. In 2011, Örebro University Medical School started a new medical programme taught entirely as PBL.

PBL and the tutor
PBL was developed in the context of medical education in North America in the late 1960s and was soon seen as a relevant and appropriate teaching-learning format for all health professionals (Barrows & Tamblyn, 1980). One goal was to educate competent doctors that were prepared to handle clinical problems. Another goal was to manage the curriculum overload that was common in medical schools at the time. By using authentic, ill-structured and workplace related scenarios as the starting point for learning, it was expected that the most relevant learning issues and material would be covered by the students and that deep learning would be achieved. During the years, PBL has been applied in different settings, not only medicine, and its effectiveness as a pedagogical method has been subject to an ongoing debate. The rich diversity of implementation and design of PBL has made it difficult to evaluate whether PBL is ‘better’ than other pedagogical models (Svinicki, 2007; Hartling, Spooner, Tjosvold, & Oswold, 2010; Donné & Edgren, 2010).

In PBL, students are trained from the very start to tackle problems that are authentic but information-poor in a stepwise sequence of activities, the so called Seven-Jumps (Schmidt, 1993). In summary, the work on a PBL scenario/case can be seen as three main steps: opening session in groups (in turn consisting of different steps), individual studies, and discussion/end phase. A tutor supports the students and facilitates the process by posing questions that stimulate reflection as well as in-depth elaboration on information and suggestions for problem solving (Chan, 2014; Moust, 2010; Roberts, 2010; Silén & Uhlin, 2008). The students get used to work out and phrase their own learning goals, to search relevant information and to construct and reconstruct valid knowledge. In PBL, students are expected to take major responsibility for their own learning and develop approaches as self-directed learners. This pedagogical model also emphasises the value of interactive and collaborative learning (Moust, 2010; Taylor & Miflin, 2008). According to Biggs (2003), PBL is a good example of a pedagogical model that is constructively aligned. In small groups, students are presented to real-world problems, designed and adjusted to their expected level of knowledge and experience. They are guided by a tutor in the process of putting theory into practice. Biggs concludes that ‘There is alignment all the way through, from objectives through teaching method, to assessment: all involve focusing on students doing what they should be doing, solving professional problems’.

In the Swedish context, the core concepts of PBL correspond closely to the Swedish Higher Education Act (Chapter 1, §8 and 9) which emphasises that students during their higher education shall develop competencies such as the ability to make autonomous and critical assessments,
'gather and interpret information at a scholarly level', solve problems and deal with 'complex phenomena', issues and situations. In addition, the Act specifies that students shall develop communication and collaborative skills to meet real situations in their future professional lives.

The role of the PBL tutor is primarily to be a facilitator who supports students’ learning and group processes. Roberts (2010) states that while much has been written about the role and experiences of the students and lately about facilitation within PBL, very few studies focus on tutors’ own experiences of their role. Our literature review shows that this still seems to be the case, and furthermore, that little has been written about PBL tutor training courses specifically.

In our literature review, we found several aspects of the tutor function relevant for our purposes here. De Grave, Dolmans, & van der Vleuten (2001) identify critical incidents that may occur in tutorial groups according to students. Most common are lack of elaboration, lack of interaction and unequal participation. The authors state that a tutor needs training in handling such situations. Other studies show that students perceive that the tutor’s performance and competence have implications on group productivity and learning effectiveness, as well as on group dynamics. This in turn correlates to students’ achievement in assessment (Dolmans & Wolfhagen, 2005; van Berkel & Dolmans, 2006). Chng, Yew, & Schmidt (2011) have studied what impact the tutor’s subject-matter expertise, social congruence and cognitive congruence had on students’ learning. They concluded that even though all three competencies are important for students’ achievements, social congruence had the most positive effect on learning in all phases within PBL groups. This suggests that the tutor has an important influence on the learning climate of the group. Roberts (2010, p. 53) writes that teachers need to be trained in order to be prepared for the important task as PBL tutor. He also poses the question of whether tutor competencies can be taught or whether the capability to facilitate is ‘naturally inherent’.

The role as PBL tutor challenges many teachers to take a different perspective on teaching and learning, and to develop new teaching skills to be able to function as PBL tutors. Williams, Alwis, & Rotgans (2011, p. 512) state that it should be of great value not only to focus on the ‘dos and don’ts’ of facilitation within the tutor development programmes, but also ‘a focus on tutors’ beliefs about learners, the psychological and emotional aspects of learning and communicating with adolescent learners’. Ho (2000, p. 30) describes that contemporary research ‘shows that university teachers hold personal conceptions of teaching that are related to their teaching practices and also to the learning of their students’. In accordance with, for example, Ramsden (2003), Ho also describes that ‘genuine improvement’ regarding how teachers think about teaching and learning has to start with teachers’ own conceptions and beliefs about key pedagogical issues. The pioneer in the development of PBL, Howard S. Barrows (1928-2011) stated that it is difficult to describe exactly the skills needed by a PBL tutor, though the key role is to help students become self-regulated learners. He quoted old oriental philosophy to illustrate this: ‘Give me a fish and I eat for a day; teach me to fish and I eat for a lifetime.’ (Barrows & Tamblyn, 1980, p. 105).

As described in the literature, the tutor plays a very important role as facilitator of student-learning processes in PBL-based education. Therefore, tutor training that includes opportunities for practicing being a tutor, experiencing occupying the student position and reflecting on learning issues together with colleagues and educational developers is commonly mandatory for new PBL tutors in Sweden and internationally (Koch et al., 1993; Des Marchais & Chaput, 1997; Moust, 2010).
In this article, we describe and discuss how tutor training is currently arranged at the abovementioned four universities in Sweden: Linköping University, Lund Medical Faculty, Uppsala Medical School and Örebro School of Medicine. We proceed to analyse how the content and format of the PBL tutor training courses correspond to the desired skills and competencies described in the literature.

METHOD

Framework for analysis
Initially, we searched for appropriate ways of analysing the Swedish PBL tutor training courses by drawing on a comprehensible description of the most important competencies of a PBL tutor. We found it fruitful to choose research articles from three pioneering universities: McMaster University in Canada where PBL was founded (Barrows & Tamblyn, 1980), Maastricht University, The Netherlands, where PBL was first introduced in Europe (Schmidt & Moust, 1995; De Grave, Dolmans, & van der Vleuten, 1999; De Grave, Dolmans, & van der Vleuten, 2001; De Grave, Moust, & Hommes, 2003), and Linköping University in Sweden where PBL was first introduced in Scandinavia (Silén, 1996; Silén, 2006). From these sources we then developed a category scheme based on recurrent themes, which we, according to our own experiences as PBL tutors, agreed upon. The categories specify the knowledge base, capabilities and skills to support students’ learning processes desirable of a PBL tutor.

Knowledge of PBL and pedagogical theories
- ability to reflect on his/her attitude towards PBL
- insight into and knowledge of different learning theories
- insight into and knowledge of PBL

Personal traits
- being able to reflect on his/her attitude towards students
- having self-knowledge of and insight into his/her role as tutor

Student-centeredness
- being committed to supporting students’ learning and their lives in an authentic way
- being able to communicate in the language used by students

Ability to handle group processes
- having knowledge of group processes
- being able to create a good learning climate
- being able to support students to cope with insecurity
- having focus on the students and on what is happening in the group
- helping students to evaluate their work by stimulating reflection
- asking questions
- challenging students, for instance, to test new hypotheses

Subject knowledge
- knowledge of the subject-matter discussed by students
- knowledge of the context (for instance, the curriculum)
Data collection and analysis
In order to investigate the current design of PBL tutor training courses in Sweden, we collected information of course design and content from the four universities studied. From these data, we constructed a descriptive text for each course and also collated an overview in a table for clearer comparison between the four courses. During the construction of data presentation, we adjusted the table as well as the descriptive texts until we found a balance in level of detail for the four settings.

The data were then analysed using the framework for analysis described above. For each sub-category the data was analysed to assess whether and, if so, how each category was represented in the courses. The results were discussed among the authors to reach consensus.

Analysis of the PBL tutor training courses
In this section, we present the key elements of the PBL tutor training courses at the four universities. In Table I, an overview of the courses is shown, highlighting similarities and differences in design. The descriptive texts are shown in Appendix 1.

General description
All the courses aim to introduce participants to PBL and group processes in PBL, and to prepare them for the role as PBL tutor. The courses last for three (Lund, Uppsala and Örebro) to four (Linköping) scheduled days of training, and also require additional time for individual study. The focus is on experiencing what PBL is, thus ‘learning by doing’, where participants act as students as well as tutors in PBL group sessions. In addition, all courses include self-studies and individual assignments, and some also include lectures (Linköping and Uppsala). The number of participants varies from 6-7 (Uppsala), 10-20 (Lund), 12-18 (Örebro) and 16-24 (Linköping). The number of participants is planned so that one or more small group(s) corresponding to the size of a regular PBL group can be formed.

Common to all courses is the heterogeneous groups of participants with different views on teaching and learning, as well as different conceptions of PBL. As many Swedish university teachers have attended courses on learning and teaching in higher education, this category can be expected to be familiar with principles of teaching in higher education as well as educational concepts such as constructivism and contextual and collaborative learning. However, many of our course participants are PhD students or post docs with no pedagogical training. Furthermore, many have a primarily clinical or research background, with little or no teaching experience, or may be more used to subject-based teaching, where the teacher has full control over the subject matter and literally transmits it to students. For those, the first encounter with PBL may evoke uneasiness and distrust of the model. Yet others have experienced PBL as students, which often means that they feel comfortable with this way of letting students take control of their learning, with the teacher as a guide. For them the challenge is instead to change perspective, from that of a student to that of tutor. It is also relevant to note that not all participants in the courses intend to become tutors. In the newly started School of Medicine at Örebro University, the course is mandatory for anyone with a central faculty leadership position on the programme. It is also common for directors of hospital clinics to attend the course to learn more about the students that they will meet in their organisation. At the Faculty of Health Sciences at Linköping University, for instance, the course is mandatory for all prospective associate professors, irrespective of whether or not the person will later act as tutor.

Course evaluations from all four universities studied reveal that participants highly value the possibility to discuss with colleagues. In accordance to the findings of Williams, Alwis, &
Rotgans (2011), course participants also appreciate the 'learning by doing' design for learning about PBL and group facilitation.

After the courses, some form of continuous educational development is provided by all universities, though not always on a regular basis.

Analysis according to our category scheme

'Knowledge of PBL and pedagogical theories': Since PBL is both a pedagogical philosophy and an educational model, a theoretical approach is important during the tutor training courses. Also, only a small number of course participants have undergone pedagogical training. At Linköping and Örebro the course participants, among other learning activities, work with theory on PBL for their individual written assignments. At Lund, PBL theory is mainly included in the case-based discussions, whereas at Uppsala theory is discussed after role-play and also highlighted during the final scenario.

Within all four courses, achieving a self-reflective perspective by participants on their own attitudes and experiences is crucial. At Linköping, for example, participants work with a scenario about thoughts and expectations of students and tutors before a tutorial meeting. They are then moved onto meta-reflections on these matters in a PBL group with peers. At Lund, one way of ensuring a reflective approach is for each participant to write a reflection on either their own experiences of being a tutor or on what they have learnt from a colleague after interviewing her/him, or joining the colleague’s PBL group. Uppsala uses, among other things, video-recorded role-play sessions, where different aspects of the process as well as tutor performance are analysed. An example from Örebro is the continual reflection on and scrutiny of the tutor role within the group after all group work. Furthermore, on all the courses, participants are challenged to manage difficult situations that may occur, and reflect upon possible tutor interventions together with peers and experienced tutors. At Lund this exercise also includes a panel of students. All courses use literature to further explore learning theories as well as theory on PBL and group processes, to help participants deepen their understanding of the role of the tutor. To further support learning, the literature is discussed at seminars where participants have prepared themselves by reading and reflecting on key theoretical works and concepts. In three out of the four courses, they are also asked to write an individual assignment. In two of the courses, at Lund and Örebro, learning outcomes explicitly state the importance of being able to reflect on and discuss the tutor role.

'Personal traits': All four courses support participants’ ability to reflect on their attitude towards students and get insight into their roles as tutors by continuous meta-reflection on upcoming situations experiences from the PBL group sessions. These discussions are conducted with peers and course coordinators. Furthermore, all courses include aspects on theory of PBL and group processes, and highlight the importance of reflections on the tutor role, as a way of enabling continuous professional development.

'Student-centeredness': Being committed to supporting students’ learning and their lives in an authentic way and developing an ability to communicate in the language used by students (that is, social congruence) are issues that participants reflect on during the courses. No less important is the ability to communicate at a theoretical level that is understandable for students. Student-centred education is emphasized in contemporary educational theory, and PBL is a
good example of such an approach. The participants apply theoretical perspectives on student-centred and student-active learning activities such as PBL group sessions, seminars, lectures and literature studies. In terms of the ‘ability to communicate in the language used by students’, this competence is not possible to develop and train in our courses since the PBL groups in the courses consist of peers rather than students. The ability to communicate with students is therefore more a subject for reflection and discussions than practice during the course itself. However, the encounter between teachers on our courses may well influence teacher identity and authenticity even if this is not addressed explicitly. The experience of being a group member during the course exercises may give some insight into students’ situations, thereby favouring reflection on how to act as a tutor to facilitate students’ learning.

‘Ability to handle group processes’: By basing the course design on active-learning methods, all course participants get the opportunity to, in some sense, ‘live through’ the process. They also read about PBL group processes, and in some cases (for instance, at Örebro) reflect upon group processes in a written assignment. By this design, the course participants experience different ways of intervention; for example, how, and when, to ask questions as a tutor. They also get the opportunity to focus on group processes and get support to reflect on what is happening and of alternative ways of handling different situations. In all the courses described in this study, discussions of and reflections on evaluation of group processes, as well as students’ own learning processes, are central. The ability to challenge students to test new hypotheses is trained during small-group activities, and is also in focus during discussions and lectures. The possibilities to support students to cope with insecurity is discussed on all the courses and is in some sense also trained due to the fact that several course participants are themselves insecure regarding PBL as a learning philosophy and educational model, a situation that must be handled during the courses. An activity much appreciated by the course participants is the role-plays that are part of the tutor training courses at Linköping, Uppsala and Örebro. The course participants at Lund handle the training of critical incidents by discussions of examples, where also a student panel comments on these discussions and this is a much-appreciated part of that course.

‘Subject knowledge’: This category is by force of circumstance not covered in depth in tutor training courses, but is touched upon to a bigger or lesser extent. At the Medical Schools at Uppsala and Örebro, authentic scenarios borrowed from the undergraduate programmes are used, which in themselves offer examples of actual teaching material. Furthermore, in Örebro, some time is spent on presenting the medicine programme, intended learning outcomes for programme units, as well as a number of guidance documents available to tutors. At Linköping, representatives from different programs using PBL discuss comparable matters with participants so that they learn more about the context in which they will work. At Lund and Uppsala, tutors are later supported in this understanding of the larger teaching context by colleagues within the different programme units where the tutors will be assigned the role of PBL tutor. This is also the case for Linköping and Örebro, since the few contextual examples presented on the course itself are not sufficient.

In summary, we conclude that all categories listed, including the different aspects on these, are being subject to course content at all four universities studied. In our analysis, we found no categories in addition to those mentioned in the literature operating in any of the courses.
Tabell 1. Table I. Overview of Tutor Training Courses at Four Universities in Sweden.

<table>
<thead>
<tr>
<th>University</th>
<th>Linköping</th>
<th>Lund</th>
<th>Uppsala</th>
<th>Örebro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit responsible</td>
<td>Centre for Educational Development (Didacticum)</td>
<td>Faculty of Medicine</td>
<td>Medical School</td>
<td>School of Medicine</td>
</tr>
<tr>
<td>Courses held since</td>
<td>1980s</td>
<td>1990s</td>
<td>2004</td>
<td>2010</td>
</tr>
<tr>
<td>Course name</td>
<td>Introductory Course in Problem-based Learning (PBL) and Group Tutoring</td>
<td>Problem-based Learning</td>
<td>Course for Tutors in Problem-based Learning (PBL)</td>
<td>Course for Tutors in Problem-based Learning (PBL)</td>
</tr>
<tr>
<td>Programmes on which tutors will work</td>
<td>Medicine; preclinical and clinical, Psychology, The IT-programme, Environmental Science, Physiotherapy, Speech Therapy</td>
<td>Biomedicine, Medicine, Hearing Therapy, Occupational Therapy, Physiotherapy, Speech Therapy</td>
<td>Medical programme, occasionally Nursing, Biomedicine and Veterinary Medicine</td>
<td>Medical programme, lately also occasionally Chemistry</td>
</tr>
<tr>
<td>Participant background</td>
<td>Professionals as above, in some courses also external participants.</td>
<td>Professionals as above and from other subjects as Biology, Engineering and Psychology.</td>
<td>Mainly Medicine, but also preclinical and clinical teachers as well as some medical students.</td>
<td>Mainly medicine, Health Sciences and Natural Sciences.</td>
</tr>
<tr>
<td>Motives for attending the course</td>
<td>Becoming a Tutor</td>
<td>Becoming a Tutor</td>
<td>Becoming a Tutor</td>
<td>Becoming a Tutor</td>
</tr>
<tr>
<td>Number of participants per course</td>
<td>16-24</td>
<td>16 (10-20)</td>
<td>6-7</td>
<td>12-18</td>
</tr>
<tr>
<td>Length of course</td>
<td>4 days</td>
<td>3 days</td>
<td>3 days</td>
<td>3 days</td>
</tr>
<tr>
<td>Scheduled hours</td>
<td>26 hours</td>
<td>15 hours</td>
<td>17 hours</td>
<td>20 hours</td>
</tr>
<tr>
<td>University</td>
<td>Linköping</td>
<td>Lund</td>
<td>Uppsala</td>
<td>Örebro</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------</td>
<td>----------------</td>
<td>-----------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Additional work</td>
<td>16 hours for individual assignment</td>
<td>5 hours for individual assignment</td>
<td>3-4 hours for individual assignment</td>
<td>4 hours for individual assignment, 2 hours for observation of an 'authentic' PBL-group</td>
</tr>
</tbody>
</table>

**Main areas of the course**

<table>
<thead>
<tr>
<th>Theory on PBL</th>
<th>Lecture and assignment (see below)</th>
<th>Case-based discussions</th>
<th>Role play follow-up, part of the final scenario</th>
<th>Assignment (see below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-group work</td>
<td></td>
<td>Learning by doing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group processes</td>
<td>Discussions, lecture, scenarios</td>
<td>Case-based discussions</td>
<td>Discussions, lecture, final scenario</td>
<td>Discussions</td>
</tr>
<tr>
<td>Reflection/Metacognition</td>
<td></td>
<td></td>
<td>In all parts of the course</td>
<td></td>
</tr>
<tr>
<td>Student perspective</td>
<td>Own experience, participants who are students</td>
<td>Own experience, student panel</td>
<td>Own experience, participants who are students</td>
<td>Own experience, student panel</td>
</tr>
<tr>
<td>Tutor perspective</td>
<td></td>
<td>Own experience, course coordinators' experiences</td>
<td>Role play</td>
<td></td>
</tr>
<tr>
<td>Critical incidents</td>
<td>Reflection during the tutorial session, role play</td>
<td>Examples discussed</td>
<td>Role play, final scenario</td>
<td>Role play</td>
</tr>
<tr>
<td>Scenario used</td>
<td>Constructed by course coordinators; concerning PBL and group processes</td>
<td>Constructed by course coordinators</td>
<td>Handed in by participants, authentic scenarios from the subject area they will work in; final scenario on PBL-group dynamics and tutor role</td>
<td>Mainly from School of Medicine, i.e. authentic scenarios</td>
</tr>
<tr>
<td>Individual written assignment</td>
<td>Based on participant's own question related to PBL as well as to literature, discussion seminar</td>
<td>Based on experience and literature, discussion seminar</td>
<td>None, but individual studies shared at end/discussion session of course scenario</td>
<td>Based on literature, shared with peers, discussion seminar</td>
</tr>
<tr>
<td>Continuous Educational Development</td>
<td>Tutor meetings are organised at the programme level</td>
<td>Occasional workshops</td>
<td>Tutor meetings held occasionally, mentoring system introduced 2010</td>
<td>Workshops, scheduled meetings for peer learning</td>
</tr>
</tbody>
</table>
DISCUSSION
The aim of this article is to describe and discuss how PBL tutor training courses are arranged today at four universities in Sweden and to analyse how the content and format of the tutor training courses correspond to the desired skills and competencies described in the literature.

Overall, we see many similarities between the four tutor training courses. All courses focus on learning by doing, with many opportunities of own experiences of group sessions and subsequent reflection at a meta level. All courses use literature as an important resource for knowledge. Participants come with different views on teaching and learning, as well as different conceptions and earlier experiences of PBL, and this provides a challenge for the course coordinators while also triggering fruitful discussions. Another challenge for course coordinators is negotiating the various impacts of participants who have been more or less forced to attend the course, some of whom may be either indifferent or even hostile to the concept of PBL, at least initially. It is, however, our experience that in many cases these more or less unwilling participants, by the end, express a positive view of both the concept and the course. The participants appreciate the active learning format with discussions with peers, experienced tutors and in some cases students.

Common to all new tutors is the need for time and space to explore their own beliefs about how we learn, to get insight into different theories of learning, and to understand the key elements of PBL. Furthermore, they need opportunities for reflecting on how we could hence teach in a way that is in line with current knowledge about how we learn. This is categorised as ‘knowledge of PBL and pedagogical theories’ and ‘personal traits’ in our study. The tutors’ personal attitudes towards PBL need first to be exposed, and the tutors’ views of the role of students as well as of the tutor, may need to be challenged. It is well known that norms, beliefs and values will influence how tutors’ act in particular situations and thereby have consequences for students’ learning (Taylor & Miflin, 2008). All tutor training courses studied spend plenty of time on reflection after participants’ experiences of group work; this in order to provide space for verbalising attitudes and views. This is in line with the view by Bowman & Hughes (2005) that tutor training programmes may benefit from a focus on tutors’ beliefs about learners, the psychological and emotional aspects of learning as well as the ability to communicate with adolescent learners. In the groups, the heterogeneity of participants’ background as well as attitudes is the driving force of a good learning experience. One central aspect brought up in all courses is the importance of being true to oneself as a tutor. That is to say, for the purpose of a good learning experience for one’s students, one needs to adopt a tutor style in line with one’s personality. This is one underlying reason why so much time is spent on reflecting on participants’ own experiences in situations that occur within the group sessions and on discussing rules for collaborative group work.

Tutors need to develop self-awareness and reflective skills, and become aware of what it means to be a reflective tutor, as discussed above. How then do the courses enable this? Our study shows that this is managed in several ways: primarily, by designing scenarios which promote reflective discussions, by assessing participants’ performance as small-group tutors during the course, and last but not least, by providing opportunity for reflection related to the role-play sessions. The focus on reflection in these four courses in Sweden is in line with what is highlighted by research internationally. In a study from Maastricht University, concerning major trends in research on the tutor role, Dolmans et al. (2002) state that developing tutor skills should be done through faculty development strategies that stimulate reflection.
Since self-directed learning plays such a prominent role in PBL, tutors also need to acquire specific skills to support a constructive learning environment and to be able to challenge students. During the four courses, tutors are trained to acquire such skills, but they also need training with real-life students to be able to act in ways that support learning processes and group interactions. Furthermore, a highly relevant aspect of a tutor’s skills is the ability to handle critical incidents that may occur in tutorial groups. De Grave et al. (2001) have identified that the most common critical incidents according to students are down to lack of elaboration by the tutor, lack of interaction between students and between students and the tutor, and unequal participation. The authors state that a tutor needs training to be able to handle such situations, which also is the case for all courses we have studied.

Today, in Lund as well as in Örebro, students participate in the courses to give their views on what they need from tutors and how they perceive different actions taken by tutors. Students have previously been invited to courses in Linköping, while today the opportunity to discuss with students is possible due to the fact that in almost every course some of the participants have experiences of studying in a PBL curriculum. In Uppsala, students are commonly participants, though in the present course set-up, student participation is not guaranteed. The opportunity to discuss the tutor role with students has a strongly positive impact on participants. In all four courses, most often there are a few participants with experiences of being former students in PBL. Hence, the student perspective is brought up in all courses in one way or another.

We have earlier specified that it is important for tutors to have knowledge about the subject discussed by students, as well as the curriculum, so that they understand how the PBL group sessions are arranged together with other learning activities such as seminars, lectures, skills training etc. to contribute to students’ learning. These matters refer to the category ‘Subject knowledge’. The possibilities and the need for including these aspects in the tutor training courses vary between the four universities. At Uppsala and Örebro, a majority of participants will act as tutors on the medical programmes. Therefore, authentic material from these programmes is used, which entails a learning experience per se. In contrast, Linköping and Lund train tutors who will later act in a great variety of programmes, and consequently the possibility to use programme-specific material is limited. For all tutors, the continuous support from the programmes on which they will be teaching is highly significant.

The tutor training courses at the different universities are all evaluated either orally at the end of the course or both orally and by an anonymous questionnaire. The contents of these evaluations are used by the course coordinators for continuous course development. In addition, other forms of evaluation have been carried out at some of the universities. Course participants appreciate a ‘learning by doing’ design to learn about PBL and group facilitation, in accordance with the findings of Williams et al. (2011). In 2010, the tutor training course in Uppsala was evaluated by a questionnaire sent to 250 tutors of which 100 replied (Persson & Hoppe, 2010). The main findings were that the course outline was considered relevant as preparation for the tutor role, that feedback from students during PBL group session evaluations can be valuable tools for continuous professional development, and that there was a need for more support from course directors or peers. Therefore, mentorship by experienced tutors was introduced from 2010 in Uppsala. In a report from Lund (Donnér & Edgren, 2006) and in Bachelor of Science (Harrangi, 2011) and Master of Science (MSc) theses (Karlsson, 2014) from Linköping and Uppsala respectively, medical students’ views on PBL, as well as on the role of the tutor, have been studied and problematised. The results show that the students find the tutor important for the quality
of their work, both for the group processes and the in-depth studies of the subject matter, and they are not fully satisfied with the support they get. The students request well-trained tutors and as the universities included in these studies already offer tutor training, further training and continuous development of tutor training skills may be needed. In 2013, an MSc thesis by Harangi focused on the tutors’ perspective. One finding was that being involved in a PBL group motivated the tutors themselves to continuous educational development as they wanted to support the PBL groups in a professional way.

We found that most participants, after a few days’ course, describe that they feel prepared enough to be able to function in a group of students. However, we are also aware of that the term ‘learning by doing’ fits very well into how tutors capture a more solid base to work from, after having interacted with different student groups. The educational idea of PBL may be understood in various ways by different individuals, and different interpretations of ideas deserve respect (Taylor & Miflin, 2008). It may take time for tutors to feel comfortable in acting as facilitators. New tutors often feel insecure about their role and are strengthened when they have the possibility to meet other tutors, as well as educational developers, and discuss different aspects of PBL tutoring. It is not only desirable for the tutors themselves that they have opportunities for exchanging experiences with other tutors, for discussing difficulties encountered in groups, and for further reflecting on their role as tutor, in workshops or other fora (see, for example, Moust, 2010, on how such sessions may be arranged), this type of training and support is also highly significant for the continuous educational development of the organisation.

We have used research from three pioneering universities to analyse to what extent the four studied PBL tutor training courses focus on the competencies needed by tutors. It can be argued that the competencies needed by tutors may have changed over the years. We believe that the fact that a new study, specifying what tutors see as good facilitation, in many ways correspond to the competencies we chose, strengthens our result (Chan, 2014).

In summary, we show that the four tutor training courses studied are all designed to offer personal experiences of what PBL is, a theoretical base and opportunities for discussing and reflecting with peers, though there are some differences in design. According to participants, they become prepared for their role as tutors. Yet, we see a need for the programmes to organise continuous educational support for tutors, after they have started their work with groups of students.

REFERENCES


APPENDIX: DESCRIPTIONS OF THE COURSE DESIGN AND CONTENT FROM PBL TUTOR TRAINING COURSES AT FOUR SWEDISH UNIVERSITIES

Linköping University
Madelaine Johansson and Lars Uhlin

At Linköping University, PBL was implemented in all programs at the Faculty of Health Sciences in 1986. This shift in pedagogy put a great demand on introducing staff to PBL and training of tutors. From the start, introduction to PBL for teachers/clinicians and training for those becoming PBL tutors has been mandatory. Different activities and courses were mainly organized within the Faculty (Kock et al., 1993). During the 90s several other programs at the university started with PBL which called for joint courses at the university level. From the late 90s till today, PBL courses are open to all staff at Linköping University, nowadays organized by Didacticum (formerly the Centre for Education and Learning).

Learning outcomes: After the course, participants will
- be able to explain the basic theoretical foundations of PBL
- have the basic skills for successfully tutoring PBL groups
- have a good understanding of how different learning activities support students’ learning in PBL-based education (for example, tutorial work, resource activities, seminars and lectures)
- have a good understanding of the significance of group processes in tutorial work
- be able to use different tools to support students’ learning in tutorial work
- have a good understanding of the various applications of PBL at Linköping University

Since the autumn semester 2013, this introductory course consists of six full days: four spent on campus and two for individual study and writing of the course assignment. The first day is devoted to an introduction to PBL and related learning theories. It also includes a lecture on group processes. In Linköping, the seven jumps have been arranged in a so-called PBL circle, containing nine steps. This PBL circle is discussed in depth to get insight into the learning rationales for the different steps and also as a preparation for day two when the participants get the opportunity to work interactively as tutors and tutorial members within this course setting. The scenario which they work through is made up of a description of the thoughts and expectations of students and tutors before a tutorial meeting. The tutorial session ends when the group has formulated a number of questions. During the afternoon, representatives from different programs using PBL at Linköping University present and answer questions. Course participants also have time for individual studies related to their tutorial work within the course. Day three consist of tutorial work related to the last phase of the problem solving process; discussing and applying new knowledge as well as evaluating, and the afternoon is dedicated to role play and evaluation. During the final day of meetings, day four, participants attend seminars in which their individual course assignments are discussed. They are then given a selection of evaluation documents for different purposes related to tutorial work. The day and the course are ended by an oral evaluation and participants are also asked to respond to an electronic course evaluation. Course participants at Linköping are learning PBL by doing PBL. The design of using PBL learning activities, such as tutorials, seminars, lectures, role plays and individual work, has
been practiced since the very beginning in the 1990s. During tutorial sessions participants get to experience what it is like acting as both tutors and observers with the purpose to get the opportunity for practical training as well as metacognitive discussion and reflection. It is clear from previous course evaluations that this design is deeply appreciated and experienced as highly supportive of the learning process.

Faculty of Medicine, Lund University
Gudrun Edgren and Gunilla Amnér

Problem-based learning was introduced at the faculty of medicine in the 1990s in order to create opportunities for students to be more active learners and to prepare them for working in and leading teams. Some 20 years later many course participants have personal experience as students in PBL-programs. The content of the course has developed accordingly.

Learning outcomes: on completion of the course, the participants shall be able to
- explain the learning principles for PBL
- use the seven steps-structure in a group
- discuss the role of the tutor in supporting the students’ learning and the development of the group, based on existing frameworks and theories

The course is designed so that participants work in small groups starting from problems or assignments using prior knowledge in the group. In this way the participants work through: learning taxonomies and theories; group functioning; process and structure; evaluation and feedback; the role of the case in PBL; challenges for the tutor in PBL. The problems used to initiate group discussions vary. The start of the course is a session where participants activate prior knowledge of and opinions on PBL. A film that has been produced at our faculty is used to start discussions on both process (seven-jump) and the role of the tutor. Course participants practice this by being students in a PBL-group that works through the seven jumps. When teaching PBL we use cases with a content unrelated to PBL and to the participants’ own disciplines, since this makes it easier to discuss the various elements of PBL. Learning taxonomies and theories are introduced through a case whereas group functioning draws on participants’ own experience of working in groups. Challenges for tutors consist of incidents in PBL-groups. The groups of participants are to present how they would deal with these incidents if they were tutors and a panel of students responds to the suggestions. Each session ends with reflections and the course leaders can answer remaining questions. The first two days of the course ends with an oral evaluation to practice giving constructive feedback. The initial session on prior knowledge and opinion is returned to and if needed revised.

After the first two days the participants have an assignment to be reported in the final day of the course. The participants can chose to write a reflection on their experience of being tutor or join a colleague who is a tutor. Another option is to interview tutors about their experience and reflect on their practice. The written assignment should be based on relevant literature. The presentations on the third day of the course are followed by a discussion facilitated by a course leader, thus giving opportunities to rehearse what was brought up during the first days. The course ends with a written anonymous evaluation.

The participants appreciate that they have had opportunities to be active during the course and been able to learn by doing. The also appreciate the presence of the students very much.
Since the beginning of the 90s, PBL-like sessions were used in the 6th and 7th semesters (internal medicine year). In 2006, a new curriculum with more student-activity was started. An important change was the introduction of small-group and case-based work with a tutor, in each group, and throughout the curriculum. Initially, the term PBL was not used, and the set-up is slightly modified from what is common in PBL. The ‘step-model’ is similar to the seven jumps, but the brainstorming is somewhat more controlled and the tutors have more specific instructions for the subject content than usual. The term PBL has been used more frequently in later years.

The first 3-day tutor course was introduced in 2004. As common for all tutor training courses, it aims at giving practical training as well as theoretical background to PBL and group dynamics, though we do not use explicit learning goals. Nowadays, about ten courses are given each year. The course coordinators are themselves experienced in PBL-tutoring and/or working with group dynamics.

The course starts with an introduction, led by the course coordinators, where the set-up of a PBL group session is introduced and common rules for collaborative group work are discussed.

The seven participants of each course form a group and take turns acting as tutor as well as being group members and the scribe, i.e. experiencing both tutor and student perspectives. The group works with the first steps in start sessions of PBL-cases (as used in the Medical School curriculum or designed specifically for the tutor training course) on subjects that the tutor in action is familiar with. All role play-sessions are video-recorded and a few minutes from each session will be shown and discussed directly after the session. Different aspects of the process will then be high-lighted by the course coordinators, e.g. the importance and value of the steps in the step-model as well as the role of the tutor for both group dynamics and in-depth subject elaborations.

Considering group dynamics, a lecture is given by a psychologist (one of the course coordinators). The last PBL-case in the course will be worked upon in full, which means that both start session, self-studies and an end session of the case will be performed, in opposite to the above described role plays where only a start session is exerted. The PBL-case is about a dysfunctional group and tutored by the psychologist, and all the participants constitute the group. The learning objectives of this case should include PBL as a philosophy/theory, the role of the tutor and how group dynamics, the step model and the rules for collaborative work can be used by the tutor in order to facilitate the PBL-sessions.

After the PBL-case closure the course finishes with remaining questions and discussion with all course leaders, followed by an oral course evaluation.

In 2010, the tutor training courses were evaluated (Persson & Hoppe, 2010) and the main findings were that the course outline is considered relevant, and that student feedback from group session evaluations can be valuable tools for continuous professional development but that more support from course directors and peers was requested, why a mentor programme was started.
The Medical School at Örebro University started January 2011, with a curriculum entirely based upon PBL. Initially, Maastricht University supported us in educating PBL tutors, and since September 2011, the courses are arranged by educational developers at the programme. Courses are mainly held at Örebro University, and since 2013, also in Karlstad and Falun, since some of our students do their clinical placements there.

**Learning outcomes:** on completion of the course, the participants shall be able to
- act as PBL group tutors in the Medical Programme
- reflect upon the role of a tutor and discuss these matters with colleagues
- describe the principles of PBL for students or colleagues lacking former experience on PBL

The course is based on experiential learning; participants learn about the different steps and aspects of the PBL-process through experiencing PBL; by being a member, a chairman, a script or a tutor in a PBL-group. The experiences are explored in discussions after each phase of the process. The first section of the course is one and a half day long. After a short presentation of the participants including their experiences of PBL and of tutoring, we introduce the medical curriculum, to illustrate the context. In order to introduce the process and the different roles in the process, we show a film of a PBL group session, and reflect on it. Then, we form groups that work together through all steps in the process. A course coordinator acts as facilitator/tutor, which offers the participants an experience from a student perspective. The group sets up a contract for common rules for collaborative group work, in line with what is done when new student groups are formed. The group works with a first scenario following the seven jumps, and finish by setting up learning goals. Day one ends with time for individual studies. Day two, the group discuss their questions and learning goals and evaluate their work. After reflection, an authentic PBL-scenario in medicine is presented and one of the participants acts as tutor, thus turning the focus to the tutor perspective. We then show examples of a variety of scenarios used in the programme.

Course day three takes place after 1-2 weeks. To stimulate a deeper theoretical reflection on learning in PBL, all participants prepare a short reflective paper based on literature, and discuss these at a seminar. This last day also include more role-plays, focusing on problematic situations that can occur in the PBL sessions, with participants acting as tutors. We also invite students to come and answer questions. Some time is spent on practical issues such as details on when tutor groups are scheduled, how many hours one tutor will be allocated for, scheduled meetings with other tutors for continuous educational development etc.

The course includes a visit in a real PBL-group on the medical program. This gives an opportunity to meet and see students and their tutor in action. The course ends with an oral evaluation in group, after which participants respond to a paper-based, anonymous evaluation.

Participants appreciate the active learning format with peer learning in group discussions, and especially the role plays, focusing on critical incidents. They also feel secure when having the possibility to discuss with students, as well as experiencing an authentic PBL group session.
SYFTE OCH INRIKTNING

**Högre utbildning** är en vetenskaplig e-tidskrift som är fritt tillgänglig enligt open access-principen. Tidskriftens övergripande syfte är att stödja framväxten av kunskap om lärande och undervisning inom högre utbildning och därigenom bidra till utvecklingen av svensk högskoleundervisning. Tidskriften utgör ett praktiknära forum för idé- och kunskapsutbyte och debatt för alla som är engagerade i högre utbildning i Sverige såsom lärare och handledare, studenter och doktorander, pedagogiska utvecklare och ledare samt forskare med inriktning mot lärande i högskolan.

Redaktionen välkomnar bidrag som kan ge fördjupad kunskap om lärande och undervisning inom högre utbildning och bidra till utveckling. Bidrag kan skrivas på svenska, engelska, danska eller norska (bokmål).

**BIDRAGSTYPER**


- **Debattinlägg.** 800 ord eller färre. Lyfter frågor av vikt för utveckling av lärande och undervisning. Svar på debattinlägg uppmuntras. Bidrag i denna kategori granskas av redaktionen.


Slutligen mottar redaktionen gärna andra typer av inlägg så som krönikor, kommentarer, reportage från konferenser och liknande av relevans för lärande och undervisning inom högre utbildning.
ÅTERPUBLICERING

Högre utbildning tillåter återpublicering av texter. Redan publicerade texter kan skickas till Högre utbildning om författaren samtidigt lämnar in till redaktionen: ursprungstexten, information om var texten tidigare varit publicerad samt om texten är i original eller i omarbetad form, medgivande från ev. medförfattare samt medgivande från ansvarig utgivare för den tidigare publikationen till att texten publiceras i Högre utbildning. Författare som har bidrag publicerade i Högre utbildning, och som önskar publicera dessa i andra tidskrifter, ansöker om tillstånd hos Högre utbildning:s redaktion. Författare får alltid lägga ut sina texter på en personlig hemsida om det görs med en hänvisning till att artikeln publicerats i Högre utbildning.

UPPHOVSRÄTT M.M.


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