Problem-based Learning in Electronic Engineering: Locating legends or Promising problems?

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Abstract
This paper examines the possibilities for using different forms of problem-based learning in the context of engineering education. It begins by exploring recent research into the way in which staff expect students to learn in higher education. Early models of problem-based learning are presented to offer some context to various modes of curriculum design. The later part of the article provides a view of more recent developments and formulations of problem-based learning and suggests ways in which it might be implemented in electronic and electrical engineering.

Introduction
As with most innovations, change is rapid yet the change is not just about the pedagogy but also the discipline, arena and practice. Some types of problem-based learning (PBL) illustrated below are possibly more flexible in their pedagogy and approach than some of the more bounded models of problem-based learning. The notion of learning through solving problems is not new, and the emergence and development of PBL reflects a number of historic changes in understandings of learning and the shaping of higher education worldwide. For example, in the 1960s educators began to question traditional teaching methods where the staff member acted as the primary vehicle of information. Such questioning began predominantly in areas of medical education where students were found to have difficulty applying their knowledge to the treatment of patients. Thus, negotiation of meaning, the focus on experience and the development of sound social practices and ideologies began to be viewed as central to the exploration of the nature of knowledge. As these ideas
converged with other contextual forces, space opened for change, and problem-based learning emerged as an innovative approach to education.

Although there are several blueprints for PBL, relatively little information exists to guide those who want to consider how to use it in terms of actually designing the curriculum in a practical way. Cultures, institutions, accreditation and professional bodies are all constraints that can affect the design of and possibilities for problem-based curricula, as are issues that tend to differ across disciplines, such as the way an essay is constructed or the way that knowledge is conceptualised.

Teaching and Learning in Electronic & Electrical Engineering
There has been criticism of engineering education, certainly in the UK, and the shortcomings were believed to be handicapping the UK’s competitiveness. In the late 1980s the then Department of Education and Science encouraged innovation in this area and particularly the introduction of studio-based degrees that had strength in design teaching. The focus then was to provide opportunities for students to work in teams, apply knowledge to problems and develop high level problem-solving skills. The result in some areas was to implement problem-based learning. Examples of this are mechanical engineering (Cawley, 1997) and automotive design engineering (Gibbs, 1992). However, the variation in technical and theoretical emphasis across current UK curricula are perhaps best exemplified in foundational models of curriculum design, whereby knowledge and theories are necessarily seen as foundational to the development of principles and other capabilities that are built on layer by layer. This model was found to be problematic by Edward (2002), who discovered that students did not expect to learn substantial amounts of theory and found it difficult both during the programme and after graduation to apply their knowledge to the practical arena. Yet since this study there has been increasing recognition by those in engineering education that have recognised the need for exploration into, and use of, other pedagogical approaches than lecture-laboratory modes of curriculum design.

Despite considerable research into different forms of education in electronic and electrical engineering, perhaps the most pertinent piece in the context of this article is
the work by Entwistle et al (2005). The authors explored the teaching practices of analogue electronics in two different departments which both taught this subject throughout a four year BEng degree. The findings indicate that there were a number of challenges relating to teaching practices, but for students one particular difficulty was in developing both analytic skills and an intuitive grasp of circuit characteristics. For example, Entwistle et al (2005) suggest:

Understanding electronic circuits thus involves a combination of intuition derived from experience, detailed analysis using problem-solving skills that involve algebraic knowledge and dexterity, and imagination in designing new circuits. This combination of skills, not surprisingly, creates more difficulty than other areas of the curriculum. Staff and students alike explained that a rather different way of thinking was required for analogue compared with digital, one which many students initially found more difficult to acquire.

(Entwistle et al, 2005)

Yet how do students develop the intuitive grasp referred to by Entwistle et al, and what kinds of learning approaches might staff adopt to facilitate the development of such intuition? Perhaps PBL might offer a means of enabling students to develop this different way of thinking. Intuition remains something that is not only difficult to define and understand but it is also complex and difficult to teach. Perhaps one of the more useful delineations of intuition is that provided by Claxton (2002) who defines intuition as immediate apprehension, without the intervention of any reasoning process and has suggested that there are 6 types of intuition:

Expertise - the unselfconscious and unpremeditated mastery of a complex domain, so that for example, an expert teacher or clinician will adjust their actions with little thought or reasoning as to why they made those particular decisions in that particular context.

Judgement - making accurate decisions without necessarily being able to justify them at the time
Creativity and problem-solving - the use of creative and unconscious processes to solve a problem

Rumination - the seeking of insight through reflecting on personal experience

Sensitivity - a heightened awareness to a situation that is both conscious and unconscious

Implicit Learning - the acquisition of expertise through nonconscious understanding and making use of patterns of information in complex contexts that are both unconscious and difficult to articulate

However, it might be that intuition is used differently according to the culture of the discipline and the beliefs about what and how things should be taught. Yet there also might be concerns about what counts as a problem and considerations about how students learn high level problem-solving that incorporate intuitive processes.

What is a problem?
The issue of what might count as a problem and the complexity of problem design is something that is a challenge to many tutors implementing problem-based learning. Some people design the problems themselves; others use templates or download problems that can be adapted. Yet the issue of problem recognition as well as problem-solving is vital in many professions, but there remains considerable debate about both how this is taught and how it is learned. For example, it is important to consider whether we are asking students to solve a closed problem by using linear problem-solving techniques or whether are we asking them to do something very different, such as using their experiential and propositional knowledge to manage a problem situation. These are two very different activities. For example, compare the two scenarios below:
Problem 1 Design a circuit for a transistor radio

Problem 2 Sony are attempting to take control of the micro radio market. You have been asked to work with a team to design an innovative radio that is of high quality and competitively priced. Using your skills as an electrical engineer, work with a team of peers to design such a radio.

Many of the arguments for adopting PBL in order to educate students for the professions stem from the idea that it will help students to transfer knowledge from university to practice. This assumption is problematic. Studies in both psychology and medical education have found that transfer from one context to another is less frequent and more difficult than is generally believed. Furthermore, Eva et al (1998) argue that the content of the problem and the problem solving abilities required of the students are two different concerns:

‘If there were only one way to solve a problem, it might indeed be possible to identify the relevant content, devise a test to measure it, then correlate it with the appropriate measure of problem-solving. Unfortunately for this purpose, there are many ways to solve a problem, ranging from a detailed analysis of the aspects of the content of the problem to a simple recognition that the problem has been encountered before’.

(Eva et al, 1998: S1)

They suggest that it is important to recognise that there are three dimensions to a problem

1. The context: the physical context of the problem and the implied task
2. The content: the semantic domain such as the disciplinary areas of knowledge and the surface elements such as the clients’ details
3. The schema or deep structure: the underlying principle of the problem

Regardless of content or principles of problem solving, it is the context in which the initial problem is presented that tends to affect the degree to which transfer of knowledge takes place. For example, a student’s ability to transfer knowledge gained
in one problem situation to another will be affected by whether the student expects the principles used in solving the two problems to be related. Schoenfeld (1985) showed that students trained on a geometry problem did not transfer their knowledge to solving construction problems because they believed that such problems should be solved using trial and error. However, Eva et al suggest that transfer of knowledge between problems of the same domain (such as chest pain) is much more likely when the context has changed. This means that we should give students the opportunity to practice solving similar problems in the classroom; in this case an example would be different clients with various types of chest pain. In PBL the problem (also often termed scenarios) is seen as the starting point for learning. The focus is on giving the students a problem that is set in a context and which invariably demands much more than linear problem-solving skills. Instead the scenarios are designed in order to challenge students to develop the abilities to recognise what the problem actually is in the context of complex data. Having done this, students then need to decide both how they will solve or manage the situations and what resources they have already within their PBL team, as well as considering what information they need to research. It is therefore vital that scenarios for problem-based learning are developed properly and are not just simple linear problems for which an answer can be found relatively easily. Thus a useful way of considering how to develop curricula towards PBL and away from narrowly defined linear problem-solving is to utilise a framework for motivational problems, such as that developed by Maufette et al (2004), below:

Table 1.1 Criteria for motivational problems

<table>
<thead>
<tr>
<th></th>
<th>Introductory</th>
<th>Intermediate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Educational Goals</strong></td>
<td>Goals are clearly stated relating to specific student actions.</td>
<td>Goals are identified and relate to suggested approaches for learning.</td>
<td>Goals are not identified in the problem.</td>
</tr>
<tr>
<td><strong>Background Information</strong></td>
<td>Draws on one source of data.</td>
<td>Draws on two or more sources of data</td>
<td>Draws on many sources of data from current practice</td>
</tr>
<tr>
<td><strong>Setting</strong></td>
<td>Complete information provided without any details omitted</td>
<td>Most information provided with some details omitted</td>
<td>Information provided with key details omitted</td>
</tr>
<tr>
<td><strong>Problem</strong></td>
<td>Clearly identifies</td>
<td>States the problem</td>
<td>Does not clearly</td>
</tr>
</tbody>
</table>
and summarizes the problem and places it in a wider context and emphasizes the wider context

<table>
<thead>
<tr>
<th>Content</th>
<th>The content is sharply focused, supported with a variety of significant details</th>
<th>The content is structured with a clear focus and supported by relevant details</th>
<th>The content covers a number of areas and is supported with a few general examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Includes self-contained independent materials like handouts and worksheets</td>
<td>Includes list of bibliographic references</td>
<td>Includes vocabulary and key concepts</td>
</tr>
<tr>
<td>Presentation</td>
<td>Tightly written with limited specialist vocabulary</td>
<td>Clearly written with a range of vocabulary used</td>
<td>Fluid writing style using extensive specialized vocabulary</td>
</tr>
</tbody>
</table>

(Maufette et al, 2004: 16)

Maufette et al suggest:

Introductory problems have all the details of the setting while more advanced problems have fewer details and rely on more inferences. Advanced problems are closely related to practice and require subtle decisions of what details the students are able to provide themselves. . . In many cases literature directly related to the problem may not exist and students would be expected to find their own information when formulating their solutions.

(Maufette et al, 2004: 17)

Having located the types of problems it might be possible to introduce with a curriculum, it will then be possible to consider the type of problem-based learning that might be adopted. Early models, delineated below are ones that fit with more traditional lecture-based courses where staff wish to control and patrol the boundaries of knowledge and ensure that certain content is covered. Some of the more recent models might be for those who want to adopt PBL in a more flexible fashion but perhaps are only able to implement it in one or two modules.
Early Models of Problem-based Learning

Problem-based learning was an approach popularised by Barrows and Tamblyn (1980) following their research into the reasoning abilities of medical students at McMaster Medical School in Canada. This was because they found that students could learn content and skill but when faced with a patient they could not apply their knowledge in the practical situation. Barrows and Tamblyn’s study and the approach adopted at McMaster marked a clear move away from problem-solving learning in which individual students answer a series of questions from information supplied by a lecturer. Thus, early definitions of PBL identify the classic model as one that has the following characteristics (Barrows and Tamblyn, 1980):

- Complex, real world situations that have no one ‘right’ answer are the organising focus for learning.
- Students work in teams to confront the problem, to identify learning gaps, and to develop viable solutions.
- Students gain new information though self-directed learning.
- Staff act as facilitators.
- Problems lead to the development of clinical problem-solving capabilities.

Soon after McMaster began its problem-based learning curriculum two other new medical schools, at the University of Limburg at Maastricht in the Netherlands and at the University of Newcastle in Australia, adapted the McMaster model of PBL and in so doing developed their own spheres of influence. The then University of Limburg, now Maastricht, began a new medical school in 1975, which saw problem-based learning as the primary strategy for the first four study years. The institution developed a new library consistent with the PBL approach in 1992 (Ebenezer, 1993), and the seven step approach whereby students

1. Clarify and agree working definitions, unclear terms and concepts
2. Define the problem and agree which phenomena require explanation
3. Analyse the problems (brainstorm)
4. Arrange explanations into a tentative solution
5. Generate and prioritise learning objectives
6. Research the objectives through private study
7. Report back, synthesize explanations and apply new information to the original problems

The seven steps developed by Maastricht are still used in curricula worldwide, although more often in subjects such as mechanical engineering, medicine, psychology and health sciences than arts-based subjects. For many staff there is an assumption that these seven steps must be followed sequentially, but since the late 1990s there have been considerable shifts and staff have omitted or combined steps, and in many cases moved away from this model all together. In the last decade PBL has changed considerably. For a once relatively stable and clear approach to teaching, with a number of models and variations which shared similar philosophies and perspectives, the current landscape is diverse, complex and contested. The result of such diversity is a landscape of both confusion and enthusiasm, which has resulted in overlapping concepts, terms, ideas and views about what once counted as problem-based learning.

Modes of Problem-based learning

Although there are a number of models and modes of PBL I will delineate several that may be helpful to those implementing it in the context of traditional lecture-based curricula where high teaching loads are common. Whilst I recognize curricula are varied both across disciplines and cultures in terms of length and design, the curricula are represented as three-year programmes since this length is common to many undergraduate programmes worldwide.

Mode 1 Single module approach
In this approach, PBL is implemented in one module (possibly two) in one year of a programme, invariably the last year. The lecturer who runs the module is interested in improving student learning and improving students’ ability to think critically, something she believes they may not have done, or not done enough of elsewhere in the degree. The module is often designed using the McMaster model of students engaging with one problem at a time and meeting two or three times over the course of each problem. Supporting lectures may appear infrequently, if ever, but the tutor
may act as a resource for the team. Students may not have a facilitator allocated to each team; instead the tutor tends to move around the team or allows the students to run the sessions themselves. The module is invariably different from all the others that the students have encountered earlier in the degree; examples can be seen in engineering (Cawley, 1997) and English literature (Hutchings and O’Rourke, 2004). The model that tends to underpin this is:

*Mode 2 Problem-based learning on a shoestring*

This tends to be implemented in modules run by staff interested in it and avoided by those who disagree with it. The result is that problem-based learning may be used in many modules throughout the curriculum (see Table 2) but there is little real rationale for its implementation in particular areas. Thus the problems used tend to be subject based and rarely transcend disciplinary boundaries. The module may have several problems occurring concurrently and staff may use lectures to guide the learning.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>PBL</th>
<th>Lecture-based</th>
<th>Lecture-based</th>
<th>PBL</th>
<th>PBL</th>
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<tbody>
<tr>
<td>Year 2</td>
<td>PBL</td>
<td>PBL</td>
<td>Lecture-based</td>
<td>PBL</td>
<td>Lecture-based</td>
</tr>
<tr>
<td>Year 3</td>
<td>Lecture-based</td>
<td>PBL</td>
<td>Lecture-based</td>
<td>PBL</td>
<td>PBL</td>
</tr>
</tbody>
</table>

Table 2 Mode 2 Problem-based learning on a shoestring

*Mode 3 The funnel approach*

In this mode, the decision has been made by the curriculum design team or head of department to design the curriculum in a way that enables students to be funnelled away from a lecture-based approach that may be more familiar to them, towards a PBL approach. They commence with lecture-based learning in the first year, then move on to problem-solving learning in their second year and then problem-based learning in their final year. Thus in the first year, students will receive lectures and tutorials and attend tutor-led seminars. The second year will comprise problems that are set within, and bounded by, a discrete subject or disciplinary area. In this year students will be expected to discover the answers expected by the tutor, answers that
are rooted in the information supplied to them through lectures, workshops and seminars. The solutions are always linked to specific curricula content, and it is expected that the students would cover this information before they can funnel into the PBL approach in the third year. The third year is designed with a cohesive framework using problems that build upon one another.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Lecture-based learning</th>
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<tbody>
<tr>
<td>Year 2</td>
<td>Problem-solving learning</td>
</tr>
<tr>
<td>Year 3</td>
<td>Problem-based learning</td>
</tr>
</tbody>
</table>

Table 3 Mode 3 The funnel approach

The decision to design the curriculum in such a way has invariably emerged from a number of tutors’ concerns that may include the following:

- Tutors’ beliefs that students need foundational knowledge and principles before they can engage with PBL.
- Tutors’ own lack of confidence in their ability to facilitate PBL teams; by using problem-solving learning first, they believe that they will develop the capabilities necessary to make them effective facilitators.
- Tutors’ beliefs that the students, on entry to the programme, are of such diverse capabilities that many of them will require considerable support in learning and that PBL will be an approach that is too difficult for many of them to undertake initially.
- Tutors’ assumptions that the professional body that validates the programme will be more content with the funnel approach, as PBL is often seen as being a high risk approach when educating students for the professions.
- Tutors’ beliefs that problem-solving learning coupled with plenty of guidance will help students not only develop the capabilities for undertaking PBL but also prevent them from struggling with it.
- Tutors feeling that it is necessary to support and take prodigious care of their students.
Mode 4 The foundational approach

The foundational approach is invariably one that is seen in science and engineering curricula. Here the assumption is that some knowledge is necessarily foundational to other knowledge and therefore it needs to be taught to the students before they can begin to solve problems. Thus, in the first year of a programme adopting this approach, the focus is on providing students with lectures, tutorials and laboratory time that will enable them to understand the required knowledge and concepts. In the second and third year, students then utilise problem-based learning. One of the underlying principles of this approach is the assumption that if basic concepts are taught first, then the knowledge will be decontextualized and therefore will be available in the students’ memories for use in solving new problems. For example, Eva et al. (1998) have suggested that the problem-solving theories concerning ways in which students transfer knowledge from one context to another fall into two broad areas:

- Abstract induction: which presumes that students learn principles or concepts from exposure to multiple problems by abstracting a general rule, thus it is independent of context.
- Conservative induction: which assumes that the rule is not separated from the problem context but that expertise emerges from having the same principle available in multiple problem contexts.

Advocates for such programmes take the view that by teaching principles of problems, students will then use these principles to solve other similar problems. Inevitably, this raises questions about the extent to which problem-solving can be classed as a generalizable skill and whether some knowledge is necessarily foundational to other knowledge.

<table>
<thead>
<tr>
<th>Year</th>
<th>Learning Method</th>
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<tbody>
<tr>
<td>Year 1</td>
<td>Lecture-based learning</td>
</tr>
<tr>
<td>Year 2</td>
<td>Problem-based learning</td>
</tr>
<tr>
<td>Year 3</td>
<td>Problem-based learning</td>
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</tbody>
</table>

Table 4 Mode 4 The foundational approach
In the foundational approach, the second year generally begins with an introduction to the concept of PBL and possibly some team building activities. The problems presented to students are ones that demand the use of knowledge and formulae presented to them in the first year. This mode tends to focus on students developing their abilities to resolve and manage problems. Students may be strongly tutor guided in this second year. However, by the third year students are encouraged to take a stance towards knowledge and are often given problems that are from, or relate directly to, industry. (For an example of this type of curriculum see Gibbs, 1992: 59-76; Savin-Baden 2000 Chapter 3, Lembert University). The difference between the funnel approach and the foundation approach is that in the funnel approach tutors are concerned to guide students towards the PBL process from early on in the curriculum. In the foundation approach tutors believe that some knowledge is necessarily foundational to other knowledge and therefore students must know this foundational knowledge before they can begin to undertake problem-based learning.

Mode 5 The two-strand approach

In the two-strand approach problem-based learning is seen to be a vital component of the curriculum that has been designed to maximise the use of both PBL and other learning methods simultaneously. This approach also tends to be adopted in universities where staff might want to implement PBL wholesale across the curriculum but who are prevented from doing so because the curriculum is serviced by other disciplines.

In the two strand approach the curriculum is seen to have clear strands running alongside one another. The problem-based modules are designed to build on each other but also to draw from the modules in the mixed approach strand. What tends to happen is that modules in each strand are designed with interlocking themes so that the knowledge and capabilities in the mixed approach feed in to support PBL rather than working against it.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Problem-based learning modules</th>
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</table>
Table 5 Mode 5 The two strand approach

Mode 6 Patchwork Problem-based learning
The patchwork approach is a complex mode that is often experienced as difficult and confusing for students. Here the whole curriculum is designed using PBL but due to institutional requirements the modules do not run consecutively but concurrently. The result can be seen in Table 6 where students undertake 2 or 3 problems simultaneously in different but not necessarily related subject areas. Furthermore, modules are unlikely to be the same length so that students may do one problem over a period of 4 weeks, another over two weeks and another within a week.

Table 6 Mode 6 Patchwork Problem-based learning

Mode 7 The integrated approach
The integrated approach is based on the principle that PBL is not merely a strategy but a curriculum philosophy. In practice, relatively few examples of this mode of curriculum exist, although it is an approach that many espouse. This model is based on the McMaster model whereby students work in teams, encounter one problem at a time and are facilitated by a tutor. The curriculum exists in an integrated fashion so that all the problems are sequential and are linked both to one another and across disciplinary boundaries. Students are equipped for the programme through explanations of the approach and team building activities. However, assessments are not necessarily structured to match the aims and values of the curriculum – although this is desirable. For example, in many integrated programmes, multiple choice questions and examinations may still be used to assess students despite the focus on the process of learning in this mode. Such assessment can thus undermine the student-centred, self-directed focus of this kind of curriculum.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Problem 1</th>
<th>Problem 2</th>
<th>Problem 3</th>
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<tbody>
<tr>
<td>Year 2</td>
<td>Problem 4</td>
<td>Problem 5</td>
<td>Problem 6</td>
</tr>
<tr>
<td>Year 3</td>
<td>Problem 7</td>
<td>Problem 8</td>
<td>Problem 9</td>
</tr>
</tbody>
</table>

Table 7 Mode 7 The Integrated approach

Applying problem-based learning to electronic & electrical engineering

Although these models of PBL are used in a variety of different curricula, it is important to consider how it might be possible to implement it in a small experimental way to begin with. For example, it is often easier to implant problem-based learning in a module or a component of a module rather than attempting to change a large lecture-based programme very quickly into something that is highly students-centred. However, even if a small component of the course is changed to PBL, students and staff do have initial difficulty in adjusting to this approach. Students often find taking responsibility for their own learning challenging and uncomfortable. Staff invariably believe that ‘teaching less’ and facilitating learning appears irresponsible because they
are not giving students considerable amounts of knowledge. Yet helping students to learn how to learn and developing the skills of research within the curriculum is vital. Yet if it is not possible to move towards PBL within a curriculum it is still possible to shift away from linear problems towards messy and complex problems that develop independence in inquiry and autonomy in students. For example, some more recent developments in problem-based learning might be useful as alternative approaches to those mentioned above:

More recent developments in PBL
The following three approaches are less well known than others but are gaining increasing interest and attention worldwide.

Problem a day
This approach was developed at Republic Polytechnic, Singapore (O’Grady and Alwis, 2002) and is termed the ‘one-day one-problem approach’. Students thus spend one whole day working on a single problem. Over the course of a week students will work on five different, but related, problems. The day occurs as follows:

- In the morning students receive a problem scenario
- Students with the help of a tutor in five groups of five (total of 25 students in a class) examine the problem and clarify what it is they do and do not know in order to formulate possible hypotheses.
- Groups identify learning issues they will investigate and employ research strategies to collect relevant information.
- During the middle of the day the groups of five meet individually with a tutor to discuss their progress.
- The groups develop an outcome for the problem and present their findings to the other four groups and the tutor for evaluation.
- Groups discuss, defend and justify their outcomes and reflect on the way they have learnt in their groups.
- Students are assessed individually for their learning and record key learning milestones in their learning journal.
This mirrors many formats adopted by other tutors in the PBL community, but it is condensed into one day. The authors argue that this approach has been adopted so that ‘students would learn highly technical skills and subject matter so they can immediately enter into specific professional occupations and apply these skills with very little additional training, but at the same time be able to adapt to the quickly changing technological landscape’ (O’Grady and Alwis, 2002).

Whilst this module has been very successful in many disciplines, there are other creative formats:

Problem-based learning in early years education

One of the difficulties in higher education is that many students appear to have lost the creativity and imagination that was encouraged in early years education. Yet models of PBL in early years education can help higher education institutions to consider how it might be used with more creativity. Much early years education was formally predominantly problem-based, following the work of Dewey (1938). In recent years there have been many government initiatives worldwide that have encouraged more formal approaches to learning in the early years. Whilst such change does reflect the ebb and flow of government initiatives there are a number of emerging models of PBL in the early years that focus particularly on collaborative group learning. The emergence of these freer forms of PBL is exemplified in work by infant/toddler and preschool programmes in Reggio Emilia, Italy. A central value in these schools is that of seeing the children as competent learners and researchers and embracing the values of a pedagogy of listening. Thus respect for the children’s needs and work drives the development of the theories about education that best serve the children. The teacher/researcher’s work ‘not only produces daily experience and action, but can become the object of critical reappraisal and theory building … practice is not only a field of action necessary for the success of the theory, but is an active part of the theory itself: it contains it, generates it, and is generated by it’ (Rinaldi, 2001: 342). The idea is that the curriculum is not child centred nor teacher directed but child originated and teacher framed. This approach is based on the following ideas:
**Emergent Curriculum:** An emergent curriculum is one that builds upon the interests of children and team planning is an essential component of the emergent curriculum.

**Collaboration:** Collaborative group work, both large and small, is considered valuable and necessary to advance cognitive development. Children are encouraged to talk, critique, compare, negotiate, hypothesize, and problem solve through group work.

**Teachers as Researchers:** The role of the teacher is first and foremost to be that of a learner alongside the children, very much like the role of a facilitator in problem-based learning in higher education.

**Environment:** Great attention is given to the look and feel of the classroom. Environment is considered the "third teacher." Common space available to all children in the school includes dramatic play areas and work tables for children from different classrooms to come together.

This is different from most forms of PBL but is perhaps an area which could be developed further in higher education. Thus, by seeing students as researchers who have prior life-knowledge, by reducing lecturing and by increasing research-focussed problems, students are likely to be better equipped for the world of work. Such an approach was undertaken in media studies education:

**Project-based problem-based learning**
This approach emerged from work undertaken with media practice educators in the UK. It is a model that became apparent through an exploration of the relationship between the use of ‘live’ project work in film studies and PBL. The study began initially because of realisation of a conflict between the kinds of work-based learning that were being expected by external organisations which were skill-based, and the kinds of problem-based and project-based learning occurring in universities. Furthermore, there is increased pressure upon academic institutions to further develop work-based learning within the curriculum. The study (Savin-Baden and Hanney, 2006) illustrated that a new model of PBL was required that reflected the values of problem-based learning whilst also recognizing the value of ‘Live Projects’ or simulated work-based learning based on “real world data”. In practice this model focuses on students acquiring skills for practice in the context of a project that is
work-related, such as making a film.

Conclusion
The diversity of the approaches available indicate a need for considerable further research in PBL, particularly in the UK, where qualitative studies into tutor roles, student experience, assessment, learning through collaboration and understanding of curriculum are to date the most prolific. Yet issues of context, difference, learning approach, understanding and impact of innovation, along with understandings of the impact of this kind of learning on professional identity and improvement, are areas that remain relatively unexplored.

References

Dewey, J. (1938) Experience and Education. New York: Collier and Kappa Delta Pi


