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Problem-based Learning: A Critical Rationalist Perspective

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Abstract

Although problem-based learning is being adopted by many institutions around the world as an effective model of learning in higher education, there is a surprising lack of critique in the problem-based learning literature in relation to its philosophical characteristics. This paper explores epistemology as a starting point for investigating the theoretical underpinnings of problem-based learning as a learning model. Criticisms of empiricism are analysed in terms of the perceived learning outcomes of learners undertaking a problem-based learning curriculum. It is argued that models of empiricism theorised by philosophers such as Bacon, Locke and Hume cannot fully account for the learning model found in problem-based learning curricula. It is proposed that an alternative epistemological approach is needed. The work of Karl Popper is discussed, whose Critical Rationalist epistemology, emphasises the generation of bold conjectures and criticism. Popper's work shows a positive contribution to the demands of higher education, characterised by learners who are serious about making professional progress. The paper concludes by critically analysing the tensions and contradictions of problem-based learning in light of Popper's epistemological theory of Critical Rationalism.

Introduction

“A genuine higher learning is subversive in the sense of subverting the student's taken-for-granted world, including the world of endeavour, scholarship, calculation or creativity, into which he or she has been initiated. A genuine higher education is unsettling; it is not meant to be a cosy experience. It is disturbing because, ultimately, the student comes to see that things could always be other than they are. A higher education experience is not complete unless the student realizes that, no matter how much effort is put in, or how much library research, there are no final answers.” (Barnett, 1990, p.155)

This quotation encapsulates the central idea of the paper. It has been argued that university teaching has stagnated and methods of teaching are out of date, due to the changing needs of learners (Biggs, 2003). Biggs claims that university classes used to contain highly selected individuals and were taught using transmission methods of teaching. Transmission methods, for the purpose of this paper, are defined as methods of teaching which holds the teacher as knowledge giver and the student as the recipient of the knowledge. Examples of this method of teaching are the traditional mass lecture seen in many universities. These transmission methods of teaching and learning produced effective learning experiences for learners 20 years ago, but Biggs argues that times have changed: ‘Universities now have a much more diverse student population and these methods now no longer seem to be working’ (ibid, 2003, p.2). It is not just the diversity of students but also the huge increase in the number of students in higher education which have given rise to a call for a more individualised curriculum which does not involve transmission based delivery (Prosser and Trigwell, 1999) Also transmission based methods of delivery can, as argued by Ramsden, have an emphasis on factual

knowledge and teacher defined goals. Work is dominated by assessment considerations and this leads to the promotion of 'surface' approaches to learning rather than deeper understanding (Ramsden, 1992).

“We have to adjust our teaching decisions to suit our subject matter, available resourcing, our students, and our own individual strengths and weaknesses as a teacher.” (Biggs, 2003, p. 2)

This is supported by Haggis who argues that transmission-based learning models used in higher education are problematic and new ways are needed to conceptualise learning in higher education in order to 'become truly accessible to the widest possible range of lifelong learners'. (Haggis, 2003, p.89)

One such popular and relatively new model of learning in Higher Education is that of problem-based learning. Problem-based learning has been a very popular learning model in medical and health degrees and research has shown that it can be an effective method of learning (Biggs, 1991; Marton and Saljo, 1976; Ramsden, 1992). Unfortunately, there is limited research to support its theoretical position (Scaife, 2000). It is therefore problematic to claim, as some research has argued, that problem-based learning can be hailed as the new model of effective learning in Higher Education (Camp, 1996; Barrows and Tablyn, 1980) especially when it has been stated that the theoretical concepts supporting Problem-based learning are:

“... are imprecise, lacking explicit descriptions of their interrelationships and of their relationships with observables, such as interventions and outcomes. In addition, the basic research is contrived and adhoc, using manipulations that seem to ensure the expected results, regardless of the theory.” (Colliver, 2000)

This has led to the central question of this paper: Is there a philosophically robust theory which can support problem-based learning? To answer this challenging question the Empiricist and Rationalist schools of philosophy will be highlighted and the work of Karl Popper will be investigated as, at first glance, Popper's philosophy of the growth of knowledge seems to be very close yet extends the fundamental principles of problem-based learning.

Problem-based Learning

Problem-based learning was initially developed in response to concerns that the academic discipline focus of a conventional university education might not be the most effective preparation for future professionals (Albion and Gibson, 2000). One of the first university courses formally designed as problem-based learning was launched by McMaster University, Canada in the late 1960's (Barrows and Tamblyn, 1980; Neufeld and Barrows, 1974). Subsequently many medical schools worldwide took this model of learning into their own courses and problem-based learning grew as an effective way to train medical and health related learners.

A problem-based learning encounter typically begins with an authentic problem of practice, without any prior preparation by learners, followed by a systematic, student-centred enquiry process. Following initial analysis of the problem, which is usually undertaken in a small group, areas of learning are identified for individual study and the

knowledge and skills acquired in this way are applied back the problem. The final reflective phase provides opportunity to summarise what has been learned and to integrate it with the student's prior knowledge. This can be expressed in a process of stages (Schwartz, Stewart & Webb ,2000; Tzannes, 1997; Moust, 1998):

1. The problem is first encountered 'cold' without any prior preparation or study.
2. A student group interacts with each other to explore their existing knowledge as it relates to the problem.
3. The students work with the problem in a way that permits his ability to reason and apply knowledge to be challenged and evaluated appropriate to his level of learning.
4. Learners identify further learning needs in order to make progress with the problem

Among the advantages claimed within problem-based learning are increased motivation and better integration of knowledge across disciplines (Boud & Felletti, 1985). The problem seems to act as a trigger to motivate learners to find out for themselves (Martin, 2000). As Schmidt and Moust state problem-based learning encourages authentic learning which can be defined as 'an in-depth understanding of the field of study, the ability to transfer knowledge to other domains and the ability of learners to reflect on their learning processes' (Schmidt & Moust, 1998 p6).

Within problem-based learning, it is claimed that it is possible to identify the following principles:

- Active: It is student centred and thus depends for its success on the energetic activity of learners (Martin, 2000);

- Relevant to the learners' goals: The stimulus statement for a problem-based learning exercise generally comes directly from the field the learners are studying. It puts the learners in the role of 'apprentice professionals', addressing real problems (Chaiklen and Lave, 1993);
- Relevant to learners' experience: It does not matter where learners obtain the knowledge or skills needed to tackle a problem-based learning problem. All of their knowledge including their knowledge from life experience is recognised and valued (Macdonald, et al, 1991);
- Learning to learn: The problem-based learning process encourages learners to use their initiative to learn (Biggs, 1991);
- Encourages learning for understanding: the emphasis in problem-based learning is on clearing up what is not well understood. Indeed some would argue that learners should not stop at arbitrary course boundaries (Savin-Baden, 2000). If group work is used then learners need to understand what they have learned well enough to be able to explain it to their peers' satisfaction.
- Encourages deep learning: As learning in problem-based learning is relevant, active, and aimed at understanding, it is likely to be deep and long lasting (Biggs, 1991; Marton and Saljo, 1976a; Ramsden, 1992).

Epistemology and Problem-based Learning

Problem-based learning is based on assumptions about learning. In turn, these assumptions arise, explicitly or implicitly, from epistemological claims. As Winch (1974) and others have demonstrated, it is very difficult and probably unwise to ignore philosophical concerns regarding the nature and growth of knowledge in our conversations about learning.

There does not seem to be a current consensus regarding the philosophical foundations of problem-based learning. For example, Schmidt (1993) locates it firmly within the rationalist philosophical tradition. Baden and Major (2004), on the other hand, associate problem-based learning with empiricism. This distinction reflects the classic characterization of epistemological schools fell into two dominant camps: rationalism or, as it is sometimes called, intellectualism and empiricism (Musgrave, 1993). Russell (1945) has suggested that the origin of this distinction lay in the Cartesian separation of the world into mind and matter. Consequently, answers to questions of the sources of our immediate knowledge of the world often fell into one of two broad groups: those asserting that it is experience (empiricists) and those that it is reason or intellectual intuition (rationalists) that offers immediate knowledge of first principles. Claims for an empiricist or a rationalist character of problem-based learning are premised on significantly different assumptions about the learning that takes place.

Empiricism, associated with the likes of Bacon (1561-1626), Locke (1632-1704) and Hume (1711-1776), can very briefly be summarized as the view that it is through our senses that we gain knowledge. Our senses allow us to know the truth of certain

propositions directly. These propositions are equated with first principles, in the light of which we can justify all other beliefs. Truth is recognized through clear perceptions. The veracity of such perceptions was linked by Bacon to the process of induction, in which discrete observations are generalized into theories. Empiricism, via induction, came to be accepted as the most likely explanation for the success of science. It has also been claimed that assumptions about the inductive nature of human learning underpins a great deal of theory and practice in school education (Burgess, 1988) and higher education (Burgess, 1977). Indeed, so prevalent is inductive thinking in educational theory that Bailey (2000) has argued that significant figures within the progressive educational tradition, including Locke, Rousseau, Pestalozzi and Dewey, with their talk of first-hand, direct experience, using the gradual accumulation of evidence, and generating theories for oneself, simply took induction for granted.

Within the history of empiricist philosophy it can be seen that the central theme that the growth of knowledge comes from experience is still held, but the theory of induction which is the method used to gain knowledge, has been claimed to be flawed by philosophers since David Hume. Hume's critique of induction states that it is not logical to assume that what has happened in the past, however many times it happens, will necessarily happen again. However, even with the critique of induction, Burgess argues that Higher Education still 'rests upon an implicit acceptance on induction' (Burgess 1997, p.131). This is something of a worry in education as inductivism fails as a theory for the advancement of knowledge. Within the inductive philosophy, as stated by Bacon (1620), observation precedes theory as it is through the senses that theories are held to be discovered. Instances in scientific history such as the discovery of penicillin by

Alexander Fleming and DNA by Francis Crick and James Watson have shown that this is not always the case and that many theories have preceded from theory guided and knowledge driven observations, in essence a deductive process.

Some have argued that problem-based learning is best exemplified in Kolb's (1984) four types of learning tasks that make up the experiential learning cycle:

- concrete experience;
- reflective observation;
- abstract conceptualization;
- active experimentation (e.g. Milne & Noone, 1996).

This model clearly shows an empiricist or inductivist stance. If problem-based learning really does follow an inductivist method, a student would come to the problem scenario without theories of the issues behind the problem; the research done by the students would be starting from nothing and because of this the research undertaken would seem destined to become undirected and resulting in confusion and miscomprehension. Within the problem-based learning process it is important for the learners to bring their own experience and theories to the problem (Savin-Baden, 2004). In this way knowledge is built upon from existing evidence and not discovered. These experiences are vital as the experiences of the group will help shape the learning process and the research which is completed will have the potential to possess greater focus and direction and ultimately finish with lucid and educated outcomes. This argument is also relevant for the role of tutors in the problem-based learning process. Their role in the process is to act as a facilitator, put more simply the role is to guide and scaffold the group work and research. If this role was seen in an inductivist stance, the tutor would be the knowledge giver and

the learners would be seen as the blank slates. Swann & Burgess (2005) supports this view, arguing that the very act of approaching the student-teacher relationship in terms of an active knowledgeable teacher giving something to the passive, ignorant student, assumes the first stage of inductivism, which is unprejudiced observation.

Another problem with inductive theory is its implicit avoidance of mistakes. In this way knowledge must be acquired without making mistakes and these mistakes or errors are seen as negative. This can be seen in many educational practises today, the strict avoidance of error in scientific subjects in order to purify the learning experience an example being in secondary school science experiments are designed to eliminate errors which might confound the desired result. Problem-based learning sees mistakes or errors as a positive part of learning. This is embodied in the concept of reflection where learners undertaking a problem-based learning course are required to reflect on the scenario and the role they have played in the process. The learners use errors to learn from and develop professionally, it is only through these errors that skills used in the problem-based learning process can be improved and developed. Therefore, it can be argued that in terms of the importance of past experience, and allowing students to be confident in making mistakes, problem-based learning as a model of learning can not fully be explained using an inductivist stance.

The rationalist tradition was characterised by an ultimate appeal to reason, or intellectual intuition, as the source of knowledge. That is knowledge is innate and it is held that through reason all knowledge can be found. The theory distinguishes itself away from empiricism by the way knowledge understood to be acquired, as it is through intellect and

deduction rather than experience and induction. Whilst empiricists spoke of the truthfulness of the natural world, rationalists, like Descartes (1596-1650) spoke of the truthfulness of God. So, first principles of knowledge were believed to be rationally self-evident, and once a rational person understands these principles, it would become obvious and beyond any doubt that they are true. Building upon these principles, the rational individual can establish the truth in other propositions. In this way, knowledge grows. This connects with ideas like metacognition and learning to learn (Biggs, 1991) in terms of knowledge being an individual construct which is subject to questioning and dialogue in order to probe the individuals understanding and lead to clearer and more refined knowledge. Savin-Baden (2004) suggests that this can be related to problem-based learning as students should use metacognitive skills and complex reasoning skills to solve problems. Prior knowledge is central to rationalist perspectives and Schmidt (1983) argues that problem-based learning provides an environment in which learners can draw upon prior knowledge. He extends this by stating that the use of scenarios prior to reading has the effect of activating prior knowledge and that this prior knowledge is then used to assimilate and comprehend new information.

It can be argued that there is a tension between strictly empirical and strictly rationalist conjectures of problem-based learning and that a better explanation, it is argued, could be found in an approach that addresses the problems evident in both empirical induction and rational deduction and that there is a role for both reason and experience, a deductive-inductive dualism. Problem-based learning as argued by Huey (2001) involves a central process of inductive reasoning, inferring a generalized conclusion from the problem statement. This conclusion, a hypothesis, is then tested on other data, which reflects

deductive reasoning. This combination of induction and deduction is often referred to as hypothetico-deductive reasoning (Bisanz et al, 1994).

Critical Rationalism

The debate between rationalists and empiricists is often presented as that between two mutually exclusive stances (Musgrave, 1993): *either* knowledge grows through experience, *or* it grows through reason. The philosopher Karl Popper, however, challenged this presentation by arguing, firstly, for the importance of both reason and experience in learning and the growth of knowledge, and secondly, that neither empiricism nor rationalism offers a wholly satisfactory explanation. From the perspective of problem-based learning, our suggestion is that the Popperian critique of traditional views of knowledge – and his alternative, Critical Rationalism - raise some searching questions regarding the nature of learning and of problems, and, therefore, of problem-based learning itself.

As stated, Popper acknowledges to certain appealing elements within the empiricist and rationalist traditions: “I am myself an empiricist and a rationalist of sorts” (Popper, 1963, p. 4). Both reason and experience play important roles in learning and the growth of knowledge, he claims, although neither has the central roles with which they have been attributed. But Popper’s most fundamental criticism of both empiricism and rationalism is that they begin with shared mistaken presumptions about knowledge and learning. Indeed, he suggests the differences between empiricism and rationalism are smaller than their similarities (ibid).

Popper's criticism of both rationalism and empiricism centred on his rejection of a number of their shared characteristics. For example, he rejected the assumption that there are any infallible foundations of knowledge, endorsing the common criticisms that neither the senses can provide an infallible source of knowledge, nor can self-evidence act as a criterion of truth (Musgrave, 1993). He suggested that the search for authoritative foundations is logically incoherent, since these foundations cannot adjudicate which are authoritative: an authority cannot be self-authenticating, so acceptance must ultimately rest on an act of faith (Parekh, 1982). A related difficulty with traditional epistemologies, according to Popper, was their unwarranted emphasis on the origins of knowledge, which conflated questions of origin with questions of validity (Popper, 1963). That is, they assume that knowledge derives its validity from its source – experience or reason – and is only valid if the source is infallible. Popper offered another view: 'there are no authoritative sources of knowledge, and no 'source' is particularly reliable' (1972, p. 134). Every potential source is welcome, he argued, be it experience, intellect, tradition or hunches, is admissible, but none has authority, as all can lead to error. So, Popper proposed an alternative to traditional epistemological questions, like 'How do you know?' and 'What is the source of your assertion?', with a fallibilistic version, 'How can we detect and eliminate error?' (Popper, 1963, p. 25). And his answer to that question is *criticism*:

“Knowledge can grow ... just because we can learn from mistakes. The way in which knowledge progresses ... is by unjustified (and unjustifiable) anticipations, by guesses, by tentative solutions to our problems, by conjectures. These conjectures are controlled by criticism; that is, by attempted refutations, which

include severely critical tests. They may survive these tests; but they can never be positively justified...” (Popper, 1963, p. vi)

Popper’s view of knowledge as “provisional and permanently so” (Magee, 1973, p. 26) highlights its relevance for problem-based learning. According to his view, learning – indeed, any knowledge-generating activity – can be best understood in terms of problem-solving (Popper, 1972). He formulated a simple schema to represent the process of learning:

$$\mathbf{P}_1 \Rightarrow \mathbf{TS} \Rightarrow \mathbf{EE} \Rightarrow \mathbf{P}_2$$

According to this schema, the learner is faced with a problem (**P**₁), usually when some expectation is disappointed, and a situation arises for which s/he is not prepared. In response, s/he throws up a tentative solution (**TS**), a trial that makes allowance for this new situation. The trial is tested in a process of error-elimination (**EE**), to see if it is adequate, and as a consequence, a new problem (**P**₂) arises that is different from the initial problem as it is now in a new situation. This is, of course, a greatly simplified schema, since learners work with many different problems and tentative solutions at the same time. The schema, however does serve to indicate the pivotal role the problems play in learning, and that learning is an open-ended and never-ending process (Nottorno, 2000, p. xxiv).

Can the philosophy of Traditional Problem-based Learning be explained in terms of Critical Rationalism

In the final section of this paper it is intended to examine Critical Rationalism in terms of a philosophical basis of problem-based learning. In principle it can be argued that Critical Rationalism can offer a tentative explanation for problem-based learning. The central themes are detailed below:

1. PBL has problem solving at its heart and encourages students to see knowledge as fluid and not predetermined;
2. Within the PBL process new problems are found all the time, it is open-ended and there are no definitive answers;
3. PBL encourages students to be critical of each others' views and experiences with reference to literature in order to clarify their reasoning and position.

The critical shift from a transmission model of knowledge growth to an increasing need to use critical methods to judge the validity of theories and ideas can be seen within a problem-based learning curriculum, as the methods used within problem-based learning encourage the process of critical thinking (Biley and Smith, 1998). This is also supported by Wetterston who states:

“Individuals do not primarily learn by imbibing information unrelated to problem solving activity.. All attempts to act as if there is such a body of truths lead to some form of deception and some form of disregard for students.” (Wettersten, 1999, p. 106)

Barnett states that the development of a 'critical being' is crucial for higher education (Barnett, 2000). Barnett (1994) argues that approaches such as problem-based learning help learners to develop independence in inquiry and to take up a critical stance towards knowledge. It has been argued that there is a theoretical basis for using problem-based learning to promote students' critical thinking (Biley and Smith, 1998; Moore, Block and Mitchell, 1990). However there have been only a few studies which claim that problem-based learning increases critical thinking (Celia and Gordon,2001, Tiwari, 1999). Problem scenarios within problem-based learning can develop criticality in learners and Barnett argues that this should be completed in stages; critical thinking, critical thought and critique. Features of 'critical thinking' include the development of autonomy and the use of reasoning skills, analysis and synthesis. 'Critical thought' includes collective learning and action and critical dialogue. Finally 'critique' involves the criticism of the discipline and taking a stance towards knowledge. Savin-Baden (2004) argues that when problems are designed in problem-based learning, thought should be given to engage learners in different levels of criticality according to their development in order to promote and develop the critical thinking skills of learners.

In many variations of problem-based learning, a critical method is used as a vehicle to allow learners to discuss their interpretations and understandings of theories. Through discussion within small groups learners are encouraged to be critical of other learners' conjectures and to support their criticisms with reference to literature. If a critical rationalist philosophy is followed, it can be argued that the theoretical frameworks or knowledge utilised in a problem-based learning curriculum are tentative and open for critical analysis. Therefore, if a critical rationalist stance is taken to underpin problem-

based learning, learners should be encouraged to follow implicitly Popper's schema, in order to illicit mismatches in their interpretation of theories which will result in an environment of critical engagement. Savin-Baden (2004) supports this by stating that if critical thinking is used throughout a problem-based learning curriculum, learners will see that engaging with a problem will not merely involve the application of a narrowly defined problem-solving skill, but a means of developing a deep understanding of the subject through critical analysis of their own theories and conjectures.

Perkinson (1993) argues that any learning model which starts with a problem for a student to explore, encapsulates a progressive approach to teaching. The term progressive education is used to describe educational ideologies that are child-centered and allow learners freedom and independence to learn without formalised learning curricula. It is widely acknowledged that problem-based learning is a progressive model of teaching and learning (Savin-Baden, 2000) and has its roots in Dewey's theories of progressive and democratic education. Within this context it is claimed that the progressive approach to teaching is concerned with the 'discovery' of new knowledge. This is supported by Margetson (1997) who argues that problem-based learning puts the learner in the position somewhat similar to that of a scientist tackling a problem and making a discovery in the process. It could be argued, therefore, that problem-based learning as argued by Margetson (1997) follows a more empirical philosophy in terms of seeing knowledge coming from without or outside the knower and therefore, allowing discovery of new knowledge through experience. This is incompatible with the critical rationalist philosophy which argues that knowledge comes from an interaction between prior ideas and experience and is actively constructed and refined. Knowledge, as argued from a

critical rationalist perspective, is not predetermined and therefore not discovered, as this implies a foundational and fixed body of knowledge. When a progressive teacher, who is employing a discovery approach like this, intervenes it is not to help students' uncover inadequacies in their understanding but to give student's help and guidance which will allow them to empirically discover the pre-exisitng solution to the problem. Also, when a progressive teacher is supporting students, praise will come when the correct solutions are given (Perkinson, 1993), again a typical empiricist teaching method. From the critical rationalist perspective there are no certain answers but plausible conjectures at a moment in time. It can be seen, therefore, that a progressive approach to learning such as problem-based learning, seems not to facilitate the process of trial and error elimination and the critique needed to allow an uncovering of the inadequacies learners hold. This subsequently does not allow them to refine their knowledge in light of critique and does not allow them to follow a critical rationalist approach to learning.

“By creating environments wherein students seemingly discover knowledge and where they perform experiments that confirm that knowledge, the progressive educator strengthens the student's belief in that knowledge; but this does not facilitate continual growth; in fact it actually hinders it.” (Perkinson, 1993 p.45)

Unasked questions

“If I thought of a future, I dreamt of one day founding a school in which young people could learn without boredom, and would be stimulated to pose problems and discuss them; a school in which no unwanted answers to unasked questions would have to be listened to.” (Popper, 1976, p.40)

This quotation from Popper highlights the argument that for knowledge to grow, learners need to ask their own questions rather than having to answer questions from other people

such as teachers. The problems have to be owned by the learner in order for true learning to take place. It is argued that the traditional model of problem-based learning does not follow a critical rationalist philosophy.

Problem-based learning requires the formulation of problem scenarios for the learners to analyse as a basis for their research and discussions. Critical rationalism requires problems to be formulated by the learner as a result of a mismatch in expectations. In many PBL curriculums, the problems are designed by tutors rather than the learners. The key question therefore is who owns the problems. Problem-based learning is characterised by Stepien, Gallagher and Workman as an “apprenticeship for real-life problem solving, that is undefined problems, incomplete information and unasked questions” (1993, p.340). This is interesting in terms of traditional models of problem-based learning as the initial scenarios that are created come from the tutors rather than the students, in essence it is the tutors’ questions and not the students’. It is difficult, however, to see any problem-based learning curriculum allowing learners to choose on an individual basis the areas of knowledge they would like to research. For problem-based learning to be effective it is important to frame areas of knowledge so that a basis can be established which then allows learners to start to test their ideas or conjectures. Learners are only able to identify unexpected and unexplained ideas when they have had time to research literature which is at odds with their expectations and discuss these unexpected experiences with their peers. This will then lead to a problem which is owned by the learner, their own question. It can be argued, therefore, that the problems faced by the learners are not initially owned by themselves but once a subject has been framed a critical rationalist approach to problem-based learning can provide learners with an

environment where they can make trail solutions to their own questions, rather than answering unasked questions which is common in more traditional learning environments. This is supported by Popper who states that traditional teaching of knowledge has its place to stimulate the interest of learners, and that learners need a degree of dogmatism before they can highlight mismatches in their learning and experience and become critical beings:

“Up to a certain stage, the teacher has to be quite dogmatic with many things. And one can say that the children need a certain degree of dogmatism. They want to be taught something. But there will come a time when the children ask intelligent questions. So the questions of where and when to be dogmatic- all of these depend on the child, on the way the child asks questions. It is an advanced stage at which you can begin to be really critical.” (Popper, cited in Bailey, 1995 p.5)

Perhaps problem-based learning cannot be fully explained by a critical rationalist perspective. However it seems it worthwhile to begin to reframe problem-based learning to convey a more critical rationalist form of problem-based learning which follows more closely the ideals set by this philosophy such as critical thinking, deductive methods of reasoning, freedom to think, read and discuss and ask questions in order to allow them to be criticised. This tentative step to reframe problem-based learning is illustrated in the table below:

Table 1: A Critical Rationalist model of Problem-based Learning

Traditional model of problem-based learning	Critical Rationalist model of problem-based learning
knowledge is	
predetermined, and accessed from without.	determined by the individual, and generated from within.
and problems are	
to be solved, as students answers converge on a specific solution	the starting point, which accepts divergence and exploration of theories.
By using	
inductive methods of reasoning	conjectures and refutations
So problem-based learning should be concerned with	
teaching of students towards set goals and order within knowledge	teaching of students to allow for multiple meanings and ambiguity.

Conclusion

The intention of this paper has been to explore the philosophical basis of problem-based learning. Empirical and Rationalist traditions of philosophy were examined as claims for different interpretations of problem-based learning are premised on significantly different assumptions about the learning that takes place. It was concluded that neither of these approaches could explain fully the practice of problem-based learning. Karl Popper's theory of critical rationalism was then examined as it could be argued that problem-based learning closely follows a critical rationalist philosophy. At the heart of the critical rationalist philosophy lies problem solving and the idea that knowledge is fallible. Knowledge or theory only holds until it is criticised. Knowledge, therefore, becomes more refined only through criticism. At the centre of problem-based learning, all knowledge or tentative theories are seen as inherently fallible but there to be discussed, argued and criticised. In this way problem-based learning closely follows critical rationalism. It is widely accepted within the literature that problem-based learning adopts a progressive approach, which is empirical in nature but does not necessarily facilitate the process of trial and error elimination and the critique needed to allow an uncovering of the inadequacies learners hold. Also it has been argued that there is a conflict with the ownership of problems within a problem-based learning curriculum. Initially the problem in the form of a scenario is designed by the tutors and not by the learners. This does not follow a critical rationalist philosophy as all learning should start with the learner's problems and not designed by a tutor. As a compromise for this criticism, it is suggested that initially in a problem scenario it is necessary for students within a group to be directed in the direction of their studies and once this has been achieved the students can then research and discuss ideas with freedom and independence, therefore generating

their own questions. Popper does acknowledge that a certain degree of dogmatism should be given to frame the initial stages of learning experience and that once this is done the learners can then find unexplained or unexpected ideas in their own experience, formulate their own problems and become critical beings. It can be seen then that in many ways problem-based learning does follow a critical rationalist philosophy but as with everything in life there are mismatches and problems which need further exploration and critique.

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