There are more answers than questions: a literature review of questioning and inquiry-based learning

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Introduction

The past 20 years has witnessed a burgeoning interest in inquiry-based learning (IBL) and research-led teaching. IBL describes approaches to learning that are based on processes of self-directed inquiry or research. Such pedagogies provide students with opportunities to engage actively and creatively with the questions and problems of their academic or professional discipline, often in collaboration with others and making use of the scholarly and research practices of those disciplines.

Research has suggested that IBL has a number of positive impacts on student learning, such as:
- Engaging students with the research practice and knowledge base of their academic disciplines.
- Developing a range of transferable capabilities, which are valuable for employability and lifelong learning, in areas such as independent learning, critical thinking, team-work and information literacy.
- Enhancing students´ enthusiasm and motivation for learning, and developing perspectives and skills that are of relevance to living and working in a complex and changing world (Brew, 2006).
- Strengthening the relationship between teaching and research in higher education (Jenkins and Healey, 2005).

Increasing effort has been expended in exploring different approaches to IBL and examining its impact on student learning. However, much of the resultant literature is at the level of descriptive or reflective/evaluative accounts of individual cases of practice, while theorisation of differing IBL pedagogies is at an early stage (Sharpe and Savin-Baden, 2007). Several commentators have suggested that the defining characteristic of IBL, as opposed to problem-based learning for instance, is its emphasis on the question as the motor for student inquiries. So, the seemingly elementary capability of identifying the question has been described as a 'critical skill' and an 'essential' foundation in IBL in pre-university education (Kuhn et al., 2000, p. 515, 520). However, as yet, there has only been minimal investigation into the role and impact of questioning in higher education, and in IBL in particular. In addition, there is little explicit guidance or support available for students or staff members who are looking to develop their questioning skills and pedagogies.

In *Research Skills for Students*, Allison et al. (1996) define research as 'seeking solutions to problems or answers to questions' (p. 4), stating that:

> 'Identifying a topic which is worthy of enquiry and then formulating a meaningful research question or questions which can be answered are probably the most difficult parts of the research activity. It is worth spending a great deal of time formulating the research questions as it is a very real investment of time and effort. Being clear about what research questions are being asked is absolutely essential as, unless you are clear, a great deal of time and energy can be wasted collecting information which cannot be used.' (Allison et al., 1996)

This is reiterated in other volumes on research methods. Brewerton and Millward (2001), for instance, note that students often find it difficult to form questions and that this is one of the most common concerns of students at the start of the research process. Despite the posited centrality of questions to the research process and their often problematic nature, very little attention is devoted to facilitating or instructing students in the formulation of their research questions or the development of their skills in asking research questions. Indeed, Brewerton and Millward (2001) suggest that students may even be inhibited in their ability and inclination to formulate research questions due to educational practices that emphasise passivity and conformity.

This review paper explores the supposition that questions play a central role in IBL. Its aim is to aid the development of inquiry-based learning pedagogies. A focus on the question allows us to better comprehend how IBL works in practice and to develop IBL designs in future. Although there is a relative lack of research into the role of questions in IBL in higher education, there is a relative wealth of material on the connections between questioning and student learning more generally and there has been some useful work on how inquiry pedagogies relate to questions in schools. This paper builds on the existing literature on student engagement with questions, and explores how it relates to the specific context of IBL, before moving on to suggest how IBL questioning might be developed in practice. There are some concluding thoughts, reflections and suggestions for the practice and planning of inquiry-based learning.

Questioning and student learning

Given the rapidly-changing and 'supercomplex' world with which students are likely to be faced after graduation, Barnett argues that it will become necessary for universities to adopt new teaching and learning regimes and adapt existing ones (Barnett, 1999). Responding to the work of Barnett, scholars such as Brew (2006) argue that one of the best ways of equipping students to meet these challenges is to provide them with opportunities to engage in genuine knowledge creation exercises that deal with the authentic problems and issues of the world. Rowland (2006) sees the creation of genuine communities of inquiry between students and teachers as another way to overcome the challenge of preparing students for an uncertain future. These thinkers on Higher Education all have one thing in common, aside from a concern that current educational practices may not be well aligned to meet these challenges; they all recognise that giving students a greater say in determining the focus of their learning, both in terms of the subjects and questions to be addressed and the processes by which they address them, has the potential to develop within students the knowledge, capabilities and outlook to succeed in life after university. Brew (2006), in particular, argues that giving students the opportunity to engage in knowledge creation, particularly through answering authentic questions that students have formulated for themselves, may be a particularly effective pedagogical approach.

The ability to ask and answer questions has long been recognised as central to successful student learning (Hakkarainen and Sintonen, 2002). Constructivist pedagogies advocated by thinkers such as Dewey (1997), Piaget (1955) and Vygotsky (1978) are predicated on the assumption that students take an active role in making their own meaning and learning. This includes offering students the opportunity to engage with questions and problems that are of direct personal and social significance, and to do so in a social and collaborative learning environment. Approaches to teaching and learning that challenged existing power relations and devolved control to the learner were also central to Freire's 'pedagogy of the oppressed' (Freire, 1970). There is thus a strong theoretical foundation for teaching and learning approaches that offer students opportunities to set and to research their own questions, and to develop the skills that will make them better questioners and researchers in the longer term.

However, it is only in the last 25 years or so that substantial empirical research has been conducted into the role of questions and questioning strategies in teaching and learning (Lewis, 1999), with a significant weighting towards developing the questioning skills of teachers rather than students (Schell, 1998; Chin et al, 2002; Kahn and O'Rourke, 2004; 2005). Although there is widespread recognition that it is important that students are able to ask the right questions, with skills like 'critical thinking and analysis' frequently appearing as subject benchmarking criteria, for example, it is only rarely treated as a central aspect of the research process, with very few published works dealing with how to formulate research questions (Alford, 1998). As was noted above, even texts which instruct students in the basics of research methodologies frequently devoted very little attention to the development of questions and questioning skills, even if they acknowledge the centrality of questions to student research projects. Student-generated questioning, however, is aligned with constructivist models of learning where students not only answer questions but become self-directed learners who identify which questions they will ask and in the process 'learn how to learn' (Schell, 1998; for more on 'learning to learn', see: James et al, 2006; 2007; Wingate, 2007). Lewis (1999) posits that a there has been a gradual shift towards questioning in pedagogic approaches and that is linked to a more general move away from students learning content to encouraging them to learn about processes (Wingate, 2007). Moreover, it has been recognised that asking questions stimulates higher order cognitive processes, makes explicit and develops understanding and promotes a range of desirable capabilities amongst students (e.g. critical thinking, metacognition, autonomy and decision-making; Pedrosa de Jesus & Coelho Moreira, 2009). Recent years have

therefore witnessed a growing recognition that it is highly desirable that students should be taught not only to engage actively with questions as set by their tutors but also to develop the ability to pose their own questions if they are to succeed in a rapidly changing world.

Questioning and inquiry-based learning

IBL has been shown to help students to develop a good understanding of the problems and questions of their discipline (Levy et al, 2007, p. 69). This may be because, as was noted previously, questions (often accompanied by problems and/or scenarios) stand at the heart of the IBL process (Spronken-Smith et al, 2007; Matthew & Pritchard, 2009). Hutchings has stated:

> 'The core of enquiry is the question, and it is in the formulation and/or the analysis of that question that the important initial intellectual activity takes place.' (Hutchings, 2007a, p. 10)

Hakkarainen and Sintonen (2002) concur, characterising IBL as a question-driven process of seeking understanding: 'without a research question there cannot be a genuine process of inquiry' (p. 27). When students have been interested in a broad theme or issue, they should be directly involved in 'determining what questions will be investigated' (Alberta Learning, 2004, p. 11), as well as the process by which the inquiry into the question(s) proceeds and the way in which it is finally presented. The issue of student involvement in determining questions is important because when students are not involved in the construction of questions (cf. Elton, 2006, p. 39) this can result in a decline in ownership and engagement.

Nevertheless, in the majority of cases, teachers define the questions into which students inquire (Brew, 2006). Although this may be predicated on the seemingly sensible notion that students need to learn about the discipline before working independently, such an alignment may actually undermine students' ability and inclination to engage in open inquiry and construct knowledge for themselves (Brew, 2006; Bereiter, 2002):

> 'The challenge in thinking about this is to design opportunities for students to explore the necessary disciplinary knowledge from the questions that they themselves generate, and to provide opportunities for students to devise learning outcomes that they themselves particularly want to achieve.' (Brew, 2006, p. 95)

This is imperative because:

> 'Given the importance of inquiry to life after they graduate, it may not matter in the first instance whether questions the students begin to research are closely related to the subject matter of their study. What is important is that the teaching has to challenge and change students' conceptions of research.' (Brew, 2006, p. 62)

Brew (2006), following Bereiter (2002), is of the opinion that, given the importance of inquiry capabilities to life after graduation, students must begin with their own questions, often those relating to the world as they experience it. Although, according to Brew, these questions need not necessarily be related to the disciplinary area of study, some practitioners have argued that by relating the inquiry to the subject 'a second layer of learning could arise specifically from students using methods native to the discipline, because this connects them to other researchers in a community of practice' (Cox et al., 2008, p. 18).
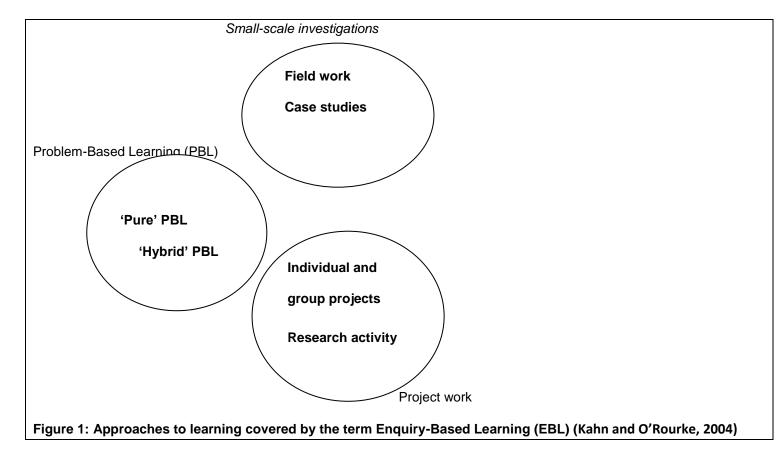
Aside from the epistemological, philosophical and practical connections between questions and inquiry, there are a number of highly practical reasons why it is useful to envisage questions as the core of any inquiry. From the development of questioning capabilities and an outlook on learning that is open to setting their own questions – which in themselves are desirable learning outcomes – students derive a number of other positive benefits:
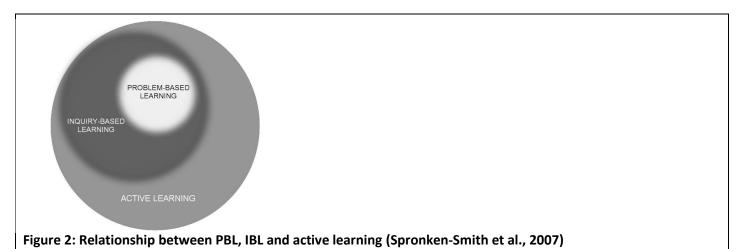
- *Questions improve students' subject knowledge*. Student-generated questions can increase their understanding and retention of textual narrative, for example (Marbach-Ad and Sokolove, 2000).
- *Student questioning develops a range of skills*. These might include 'higher-level thinking skills such as critical thinking' (Schell, 1998) and the ability to construct new disciplinary knowledge (Chin et al, 2002; Kuhn et al., 2000).
- *Questions provide an opportunity for monitoring student learning*. In posing questions students both shape and expose their thoughts; this also provides opportunities for teachers to monitor students' thinking and conceptual understanding (Marbach-Ad and Sokolove, 2000). In some cases, therefore, student questions can actually help teachers to transmit their expert knowledge, aid them in assessing students' existing knowledge and provide a basis for selecting and sequencing content (Schell, 1998).

- *Questions promote engagement with disciplinary ways of thinking and acting*. Emphasis on student questioning conveys the message that the discipline itself is an area where *inquiry* is a natural component in which questions should constantly be raised (Marbach-Ad and Sokolove, 2000).
- *Questions create opportunities for mutual exchange between students and teachers*. The teachers' understanding can be provoked by student questions, helping us to reach a broader understanding (Marbach-Ad and Sokolove, 2000). Hakkarainen and Sintonen (2002) suggest that collaborative inquiry questioning had a positive impact on school students' questioning skills: 'social communication pushed a student to pursue question-driven inquiry further than he or she might originally have been able to go' (p. 39).
- *Questions have a beneficial effect on students' motivation to learn independently and engage with the learning process*. Students prefer having the opportunity to be more directly involved in asking questions and to participate directly in exercises, impacting directly on their interest in the material being covered and the effort they are willing to put into class (Gibson and Chase, 2002; cf. Norman and Schmidt, 2000). Cox et al. (2008, p. 15) report that their first year Information Studies students 'enjoyed having the freedom to research their own questions despite (some said) this being challenging.'
- *Questions improve students' awareness of the learning, inquiry and research processes* (Chin et al, 2002). Loyens et al (2008) report a positive correlation between Self Directed Learning, Self Regulated Learning and PBL, with particular emphasis being placed on students' ability to identify learning issues and learning needs – defined as identifying questions to be asked of the literature on the learning issue.

The 'problem' in problem-based learning

Inquiry-based learning (IBL) has emerged as a distinct pedagogy over the past two decades, and during that process there seems to have been a tendency to associate it with problem-based learning (PBL). Some proponents of IBL see it as an overarching category which subsumes PBL, as is suggested by the following diagrams.

Figure 1: Approaches to learning covered by the term Enquiry-Based Learning (EBL) (Kahn and O'Rourke, 2004)

Figure 2: Relationship between PBL, IBL and active learning (Spronken-Smith et al., 2007)

However, despite the frequent conflation of PBL and IBL and the possibility of subsuming PBL within IBL, the association between the two cannot be maintained fully when they are compared in detail. Supporters of more rigid, predefined and systematic forms of PBL, especially those found in medical curricula, for example, would reject any conflation. For them, PBL is a distinct pedagogic approach that is directed towards the development of specific professional knowledge, attitudes and competencies that stand apart from the open-endedness inherent in IBL (Savin-Baden, 2000; Savin-Baden and Major, 2004). Indeed, Brew (2006), has suggested that the key differences between PBL and inquiry-based learning (PBL = tightly structured problem-solving; carefully designed sequence of steps to be followed; problems to be addressed are set by tutors; collaborative student inquiry, not including teachers; teacher research is kept separate from the student learning experience) actually militate against a genuinely research-based undergraduate education. 'Purer' forms of PBL therefore do not often give students the opportunities to set their own questions or to engage in meaningful knowledge-building and as such are very different from 'purer' forms of IBL.

According to Spronken-Smith et al (2007), inquiry courses are question driven rather than topic or thesis driven; they *often* involve open-ended questions, while problem-based learning (PBL) *usually* focuses on questions to which answers already exist. There is, however, some sort of relationship between less rigidly-defined forms of PBL and IBL, where the PBL approach may be more 'open' to student control of the problem and of the process of investigation and the IBL may be more 'closed' and teacher-led. There may thus be some value, in exploring the role of problems and questions in PBL because it may shed an illuminating light on the role of the in IBL.

It has long been recognised that the quality of problems used in PBL classes has a major influence on the quality of student learning. However, despite the importance of problem quality, 'not much is known about what contributes to the problem quality' (Sockalingam & Schmidt, 2007). This is unsurprising, since there is no consensus about the definition of PBL itself or of role of problems in PBL. In her review of the PBL literature, Maudsley (1999) quotes a number of different definitions of the PBL 'problem':

- 'an unsettled, puzzling, unsolved issue that needs to be resolved';
- 'a set of phenomena in need of some kind of explanation. It is a situation that is unacceptable and needs to be corrected';
- 'a set of circumstances in a particular setting which is new to the student […] where specific items of knowledge and understanding have to be applied in a logical analytical process in order to identify the factors involved and their interaction';
- a scenario that, to be understood, requires learning rather than solutions;
- a curriculum in which knowledge arises *through the process* of working on a problem rather than knowledge being a *prerequisite for* working on a problem;
- a case using a 'problem simulation format encouraging *free* inquiry';
- an approach to learning where the starting point is a problem; an overall approach; a student-centred approach.

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Despite such definitional disagreements, there is general consensus that problems stand at the centre of the PBL process – it is the subsequent role and functioning of that problem which is at issue, as with the place of questions in IBL. Yet the generation of questions is an integral part of the PBL process, just as it is in IBL:

> 'the students assess their learning issue, a stage which is essentially about question formation. At this point students generate questions about what needs to be explored in the literature on the learning issues which they have identified. This process can be iterative, with further questions being generated by each stage of research, reporting and reflection.' (Loyens et al, 2008)

However, unlike IBL, in PBL the initial problem is usually set by the tutor and the process by which it is broken down and researched is also more likely to be pre-defined and tutor-led. For example, in medical education students mostly encounter problems that require solutions and tutors may therefore want to guide them in the direction of that solution and train them in processes that are more likely to result in the correct answer (Loyens et al, 2008).

In other disciplines, however, the problem either does not need to be solved or is inherently not capable of being solved. Hutchings (n.d.), an early proponent of the adoption of PBL into literary studies, states that in PBL students are presented with scenarios rather than 'facts' to be learnt for an exam. The students then explore, investigate, research and propose responses to the scenario. Effective PBL scenarios in literary studies will therefore act to stimulate students to engage in an active, and often open-ended, process of discovery (Hutchings, 2007a). There thus seems to be a divide between PBL in more the 'hard' disciplines, where there is a stronger imperative towards students attaining a known 'correct' answer and in the 'softer' subjects, where open-endedness about both process and content are more often encountered. As we shall see, this disciplinary dichotomy has been carried over into discussions of disciplinary conceptions and practices of IBL.

A motivating context: authenticity, ownership and motivation

> 'Authentic education is not carried out on by 'A' *for* 'B' or by 'A' *about* 'B', but rather by 'A' *with* 'B', mediated by the world – a world which impresses and challenges both parties, giving rise to views or opinions about it. These views, impregnated with anxieties, doubts, hopes, or hopelessness, imply significant themes on the basis of which the program content of education can be built.' (Freire, 1970, p. 74)

An effective IBL scenario (or question, proposition, topic, etc.) should act 'as a spur to a sequence of additional examinations' (Hutchings, 2007b, p. 3). The stimulus provided by the scenario motivates the student(s) to search for missing evidence, sources of knowledge or ideas, which are then tested for validity and relevance.

Given the importance of the scenario to the success or failure of an IBL exercise, it is imperative that course designers successfully identify a 'motivating context' for IBL (Edelson et al., 1999, p. 440). Constructivist pedagogies have traditionally placed a strong emphasis on importance of 'authenticity' in the learning process, and this is largely replicated in the literature on the development of student questioning and inquiry-based learning (Dewey, 1938; Hutchings, 2007a, p. 11: 'the power of Enquiry-Based Learning is that it is aligned with living'). Loyens at al (2008) propose that one reason why PBL increases students' motivation to learn is that the problem is often related to their professional practice. Both Bereiter (2002) and Brew (2006) have described genuine knowledge building as starting with questions that people want to ask about the world as they perceive it:

> 'Thus, for the teaching of research methods to be successful, attention needs to be focussed on the development of authentic questions in which the students have an interest.' (Brew, 2006, p. 62)

The literature on the relationship between questioning and student learning also stresses the importance of engaging students with issues that are of personal or societal relevance and of meaning to their lives. Inquiries that are less relevant for students are likely to generate less interest and can create barriers to engagement in the short and long terms (Edelson et al., 1999). White and Frederiksen (1998, p. 87) report that one of the main challenges they faced in setting up an inquiry-based science curriculum was 'to create inquiry and reflection activities that are motivating and meaningful to students'. A large number of studies report that student engagement is far easier to achieve if the questions with which they are engaged are authentic in nature and/or provoke personal interest or 'ownership' on the part of the student(s) (Alberta Learning, 2004; Whowell, 2006; Pedrosa de Jesus & Coelho Moreira, 2009 on chemistry; Davis, 1994 on language teaching; Cox et al., 2008 on Information Studies).

Personal relevance could be defined in a number of different ways, but includes the opportunity to formulate meaningful questions related to: professional practice (Plowright and Watkins, 2004); to the students themselves

and their relationships to family and community (Justice et al, 2007); to 'relevant, high-priority, community-oriented issues' (Maudsley, 1999); and to disciplinary ways of doing things (Wyatt, 2005; Edelson et al., 1999). It is therefore important that inquiry projects are of inherent interest to the students and do not focus solely on process or methodology (Crull and Collins, 2004; see also Donald, 2002, p. 166 for an example from Psychology). Effective starting points for IBL can be drawn from real life, the world of professional practice, or the personal interests and experiences of students. This holds true for inquiry activities across all levels of the educational system and all disciplines (Memory et al, 2004).

A question of discipline

Questioning is perceived by practitioners to be a central element of the practices and processes of virtually all discipline areas (Donald, 2002; Hounsell & Anderson, 2009). This may be articulated in slightly different ways in the various disciplines, from a focus on problem-solving in the applied sciences to critical thinking in the humanities, but the abilities to pose, break down, inquire into and answer questions are fundamental ways of thinking across the disciplinary spectrum (Donald, 2002). However, in spite of the centrality of questioning to disciplinary identities, students are provided with the opportunity to develop their questioning skills, to acquire a positive attitude towards setting their own questions and even to pose inquiry questions of their own on surprisingly few occasions. This is unfortunate, because:

> 'Research requires that we relearn this skill; that when we read, we actively engage in the material by asking questions of the text and raising queries and challenges. Many students do not feel confident enough in their ability to do this, feeling that they do not know enough to warrant the taking of a critical and reflective stance. But how much knowledge does one need in order to decide that now is the time to start questioning and reflecting?' (Brewerton and Millward, 2001: p. 42)

Some research has suggested that before students can be required to set their own inquiry questions they need to have acquired a basic level of domain and metacognitive knowledge. It may be possible to justify this position if we accept that we must ensure that students learn a certain amount of disciplinary knowledge and such a vision aligns well with the modular structure of modern-day degree courses, which have clearly specified outcomes that are designed to meet accountability requirements (Brew, 2006; Matthew & Pritchard, 2009).

The idea that disciplinary knowledge may be a necessary basis for independent inquiry supposes that students who lack prior knowledge might ask lower-order questions that could be insufficient to activate or enhance their or their peers' knowledge and/or reflective thinking (Choi et al, 2005). In the context of science education, Edelson et al (1999, p. 400) state that the 'formulation of research questions, the development of a research plan, and the collection, analysis, and interpretation of data all require science content knowledge.' Oberg (1999) suggests that increased subject knowledge impacts positively on school-age students' ability to ask meaningful questions and their motivation in following up investigations into those questions. Knowledge of content is thus viewed as being integral to the inquiry process in these two cases. However, this view of prerequisite disciplinary knowledge can be challenged as too simplistic. It is contested by Hakkarainen and Sintonen (2002), who suggest that even students who do not know topics very well are able to generate cognitively valuable questions, even if they are unable to provide answers to those questions.

Assumptions are also made within different disciplinary contexts about appropriateness of students asking questions. The link between IBL, questioning and disciplinarity is made plain in a number of studies where it is argued that IBL was a suitable way to describe and teach disciplinary practices because questioning is of such fundamental importance to the discipline. Asking questions is seen as central to the identity of disciplines such as Theology and Religious Studies by both staff and students and it is thus frequently replicated in disciplinary pedagogies (O'Loughlin, 2010). Other research suggests that questioning and IBL are well aligned because there may be no known answer to the questions which are posed in the discipline and that students therefore need to be less reliant on the research of others and need to become familiar with posing their own questions (Plowright and Watkins, 2004). Elton (2006) suggests that students in arts and humanities based subjects are more likely to construct their own problems or questions, in contrast to more traditional, practice-based subjects in which such problems are constructed by teachers and simply presented to students to solve. Arts and humanities disciplines might therefore be more suited to IBL pedagogies than science disciplines, where problem-based learning and problem solving are more prevalent.

Edelson et al. (1999) allow us to nuance the dichotomy between the humanities and the sciences. They suggest that science, as a discipline, is inherently a question-driven, open-ended process but that students must have first-hand experience of science to understand this aspect of the discipline. Two of the main characteristics of successful IBL topics of investigation in the science disciplines reinforce the centrality of prior knowledge to meaningful student engagement in science IBL: that the topic is a matter of legitimate uncertainty and controversy in the scientific community; and that the topic is familiar to the students (Edelson et al., 1999; cf. Kuhn et al, 2000). Other researchers have suggested, however, that even school age students can 'be engaged in the same kind of extended processes of question-driven inquiry as scientists and scholars' (Hakkarainen and Sintonen, 2002, p. 27). Likewise, Pedrosa de Jesus and Coelho Moreira (2009), argue that it is best if Chemistry students are presented with scenarios which promote the generation of 'open' and 'quality' questions which are more likely to lead to the resolution of the problem under consideration, also noting that their students generated more higher level questions when the problems they were presented with were more closely aligned with the discipline.

Although the assumed key difference between the disciplines is that students in the sciences need prior knowledge, experience and skills in order to engage in IBL and therefore ask their own questions and that for humanities such preconditions are less important, the literature does not seem to support this dichotomy. Trowler (2009), for example, takes issue with the position that disciplines determine thinking about teaching and epistemology. For him, the issue is far more complex, discipline is only one factor amongst many, with issues such as individual agency and disciplinary and other structures in constant (and often changing) dialogue.

Some of the more recent literature on questioning and IBL has sought to move out of this disciplinary impasse by refocusing the discussion on the importance of interdisciplinary questions. Kreber (2008), for example, has underlined the importance of 'subjects' as opposed to disciplines. For her, subjects, such as social justice and other issues of social importance, are more important than disciplines in the modern world and should thus form the raw material for student inquiries, from which they can generate meaningful and authentic questions of their own. Coming at this matter from a slightly different perspective, Bereiter (2002) argues that the question is more important than the discipline and that it may matter less what the question is about in terms of subject matter or discipline, than that the student has responsibility for asking it. Even student feedback on discipline-specific question-posing has emphasised that students perceive question asking to be of value in other academic contexts and for their future professional lives; it is not stored in a disciplinary 'box' (Pedrosa de Jesus & Coelho Moreira, 2009). These and other studies align interestingly with current moves to promote interdisciplinarity in Higher Education. Together, they may signal a shift in emphasis away from the idea of acquiring 'bodies of knowledge' (disciplinary emphasis) and more towards the idea of responding to complex cross-cutting issues, problems and questions (interdisciplinary emphasis).

Levelling and progressing the question

As was noted above, opinion is somewhat divided over the issue of when students should be expected to engage in setting their own inquiry questions. In the literature, discipline seems be a significant mediating factor, with students in humanities subjects expected to generate their own inquiries earlier in their studies than more scientific, professional and applied disciplines. Practitioners are particularly concerned that the ways in which questioning is presented to students and the support which the process of questioning receives from staff should be appropriate to the 'level' of the students. In most studies, 'level' corresponds to the year of study of the students concerned. Hutchings (2007a; n.d.), for example, suggests that work on scenarios at higher levels should involve students in posing their own questions. So, appropriate questions are either not given, so that students have to tease out their own responses to the scenario (i.e. identify which questions are important) or further questions should follow from the initial question. Edelson et al. (1999) describe how their inquiry based course progressed from simple to complex activities and from specific instructions to open-ended tasks that were designed to expose students to the techniques they would require later on in an initially guided fashion; they were then allowed to gain experience in deciding which techniques to use through more open-ended tasks (cf. White & Frederiksen, 1998, who scaffold students from relatively simple, small inquiries to those on a larger scale). This may well correlate with what we know about how students progress through different levels of question specificity, from vague notions of information need to clearly defined needs or questions (Oberg, 1999). However, Brew (2006) contends that

students, no matter what their prior level of knowledge or education, can achieve a great deal through IBL, given the right support and framing for questions.

Rather than focussing on the level of study, it might be more productive to examine the issue of the level and progression of questioning activities in terms of the level of epistemological and personal development of individuals and groups of students. Baxter-Magolda has shown that students vary considerably in their understanding of the nature, certainty and limits of knowledge and this may affect their ability and willingness to accept a share of authority with their teachers and thus to take on the responsibility of setting their own questions (Baxter-Magolda, 2009; McArthur, 2009). This should lead us to question the simplistic assumption that students in the first year of university should be engaged in asking their own questions either infrequently or not at all. Indeed, some of the literature on school-age inquiry and questioning suggests that the disposition to engage in independent self-generated inquiries may be stronger in younger pupils than older students (Alberta Learning, 2004; Hakkarainen and Sintonen, 2002). Efforts to refocus the debate about levels on intellectual development rather than year of study run parallel to the attempt to move away from the existing emphasis on students acquiring disciplinary knowledge and skills before they are allowed to engage in independent inquiry and set their own questions.
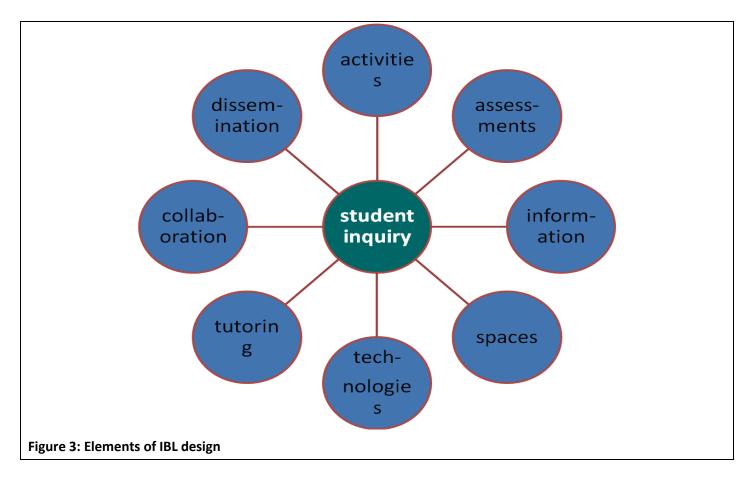
Support and scaffolding for questioning

Commentators are virtually unanimous in sharing the opinion that student engagement with inquiry questions and questioning should be supported because the process of question generation and investigation involves students progressing 'through levels of question specificity, from vague notions of information need, to clearly defined needs or questions' (Alberta Learning, 2004, p. 79). 'Posing researchable questions and pursuing them through open-ended investigations are abilities that must be learned' (Edelson et al, 1999, p. 393) and such learning inevitably requires some form of pedagogic support. This support, or 'scaffolding', can range from highly scaffolded and technologically assisted structures that are made visible and explicit to the students (White & Frederiksen, 1998) to minimal or implicit scaffolding. Schell (1998) states that in order to develop their capabilities in questioning students require scaffolding in the form of guidance, time and practice. Spronken-Smith et al (2007) note that some students may feel uncomfortable with inquiry-based approaches, especially when first confronted with such pedagogies and/or when asked to engage in inquiry in the classroom (Marbach-Ad and Sokolove, 2000). Reasons for this may include students not wanting to draw attention to themselves and/or teachers feeling uncomfortable with students asking questions. Potential student reluctance to engage in inquiry and in setting questions (Crosby, Pattison & Skilton, 2002) thus makes it doubly important that they receive support, guidance and encouragement when first engaging in IBL.

As was noted in the section above on types of IBL, at the highest level there is a difference between teacher-directed inquiry projects, where students have a choice of topics on which they can work, and student-directed inquiry projects, where the teacher may provide curriculum-related themes and allow students to generate their own topic questions (Alberta Learning, 2004; Spronken-Smith et al, 2007). The crux of the matter is how the space between these two approaches is negotiated and supported in practice, while taking account of what we know about processes of questioning. Appropriate activities (including in some cases the didactic delivery of material by the tutor to the students) and resources should therefore be provided to support the process of engagement with IBL and questioning (Hutchings, 2007a). For example, in their description of a generic inquiry course, Justice et al (2004) emphasise the amount of effort that they expended in supporting students through the questioning process – the route by which students understand, engage with and ultimately answer the questions that they are given (or preferably develop for themselves). Edelson et al. (1999) note that in their intervention it was necessary to create a series of 'staging activities': short, structured investigations designed to build understanding of the research techniques and develop subject understanding.

Given the widespread acknowledgement of the need for questioning and the development of questioning skills to be scaffolded, the following section summarises some of the most pertinent themes connected to scaffolding/supporting questioning. As a heuristic device we will be using categories derived from a conceptual design tool developed by the Centre for Inquiry-based Learning in the Arts and Social Sciences (CILASS: https://www.shef.ac.uk/ibl/cilass) at the University of Sheffield to support engagement with and development of IBL curriculum development projects. Based on experience of developing a range of IBL projects across the arts and social sciences and on a programme of empirical evaluation and research, the following diagram represents the

various factors which should typically be considered when designing an IBL course (Levy et al, 2011). A number of these factors can be related to the scaffolding of inquiry questioning activities and should be considered by anyone designing an IBL course that specifically aims to develop students questioning skills or uses student-generated questions as the driver for the inquiry-process. It should be noted that these categories are not rigid, that in some cases there is considerable overlap between them and that some of the categories are less relevant than others. For instance, 'learning spaces' and 'learning technologies' may not be directly relevant to the issue of questioning, but it is important that they are considered in the planning of any inquiry-related teaching and learning event or process. Relevant learning technologies can provide a platform for students to interact, generate and share questions, while appropriate learning spaces are necessary if students are to be encouraged to participate actively in class, including asking questions and responding constructively to those of their peers and tutors.

Figure 3: Elements of IBL design

Student inquiries – student questions

Questions lead inexorably to the issue of answers. Many students and teachers have been conditioned to believe that there is a single 'right answer' to each question and that it is the aim of education to find that one specific answer (Wyatt, 2005). Teachers and students may thus be reluctant to assign responsibility for the setting of questions to students, who they might feel have fewer skills and less subject knowledge associated with the topic under consideration. However, in an IBL context, it is particularly important that the inquiry questions are 'complex and open to various approaches and interpretations' (Justice et al, 2007, p. 205; Kahn and O'Rourke, 2004, 2005) because in some cases many of these approaches and interpretations may be intellectually and simultaneously valid (Hutchings, 2007a; n.d.). Research into the role of questions in PBL has concluded that open-ended statements are a better way of generating questions and sharing knowledge between student groups (Abrandt Dahlgren and Öberg, 2001, p. 276). The openness of IBL may therefore lend itself to the promotion of, and could also be the product of, student generated questions. In 'pure' IBL, therefore, questions and inquiries are thus in something of a symbiotic relationship. Inquiry-based learning requires that students and teachers recognise that: 'With original research there is no 'right' answer to find; there is only data to be collected. Students must learn to think and to evaluate that data, and trust the process of so doing. They also must be willing to be wrong' (Wyatt, 2005, p. 84).

Recent studies have focused on the kinds of inquiry in which students are engaged. Research carried out across a number of higher education institutions in New Zealand (Spronken-Smith et al, 2008; Spronken-Smith and Walker, 2010) identified three different kinds of IBL:

- **structured inquiry**, where teachers define the issue or problem to be explored by the student(s) as well as providing them with a pathway for addressing it;
- **guided inquiry**, where teachers provide questions to stimulate inquiry but students have greater self-direction in terms of how to explore the questions;
- **open inquiry**, where students formulate the questions themselves as well as going through the inquiry cycle largely independently.

This schematic thus envisages IBL as ranging across a spectrum, from rather structured and guided activity (generally at lower levels) to open inquiry or independent research where the students generate the questions and determine how to research them (at higher levels) (Spronken-Smith et al, 2008; Spronken-Smith and Walker, 2010). All of these approaches can begin with a question, although open inquiry frequently starts with a general theme from which the students can develop the specific question(s) to be addressed (Spronken-Smith and Walker, 2010). When considering the practicability and desirability of engaging students in inquiry related questioning or activities designed to support the development of questioning skills it is important to bear in mind the level of the student, the discipline, the scale of the planned activity (single sessions up to a whole degree), and the approach favoured by the tutor. The level of scaffolding that is provided by the teacher should decrease as the students move from structured to open inquiry, while the students are expected to engage in an increasing amount of independent research activity over the same period (Spronken-Smith et al, 2008; Spronken-Smith and Walker, 2010). This suggests that as they progress through their studies and gain more experience, knowledge and skills, the students should be given greater control over the questions that they ask and how they address them.

Ongoing qualitative research by the Centre for Inquiry-based Learning in the Arts and Social Sciences (CILASS) at the University of Sheffield into student and staff experiences, conceptions and practices of inquiry based learning provides another useful interpretive framework against which to situate the discussion of the role of questions in inquiry-based learning (Levy, 2009; Levy and Petrulis, 2012; Wood and Levy, 2009). Research into first-year undergraduate students' experiences of inquiry and research in arts and social sciences disciplines revealed two main conceptual frames through which students viewed their experiences of inquiry and research (Levy and Petrulis, 2007). These conceptual frames are labelled on the horizontal axis of the matrix (figure 4 below) as the 'information' frame and the 'discovery' frame. When viewed through the information frame, students experienced research and inquiry as the exploration and acquisition of existing disciplinary knowledge. When viewed through the discovery frame, they experienced research and inquiry as participation in building on, and contesting, that knowledge. The horizontal axis adds a further dimension, classifying students' experiences according to the extent to which their accounts emphasised student- or teacher-led processes. The dimensions of the matrix are continua rather than oppositional binaries and in practice inquiry experiences (and pedagogical designs) may combine different approaches.

STUDENT-LED

Pursuing (information-active)
Students explore a knowledge-base by pursuing their own questions and lines of inquiry ("what is the existing answer to my question?").

Authoring (discovery-active)
Students pursue their own open questions and lines of inquiry, in interaction with the knowledge-base of the discipline ("how can I answer my question?").

EXPLORING AND ACQUIRING EXISTING DISCIPLINARY KNOWLEDGE

PARTICIPATING IN BUILDING DISCIPLINARY KNOWLEDGE

Identifying (information-responsive)
Students explore the knowledge-base of the discipline in response to questions or lines of inquiry framed by staff ("what is the existing answer to this question?").

Producing (discovery-responsive)
Students pursue open questions or lines of inquiry framed by tutors, in interaction with the knowledge-base of the discipline ("how can I answer this question?").

STAFF-LED

Figure 4: Inquiry-based Learning: a framework (Levy, 2009)

Questions play an integral role in understanding how IBL might be experienced by students, and hence where any inquiry might be positioned, along the axes. The degree to which staff or students frame the inquiry question and process by which it is to be pursued determines where any given inquiry-based learning activity might be mapped against the vertical axis. Likewise, the extent to which questions that are generated in the course of an inquiry engage students with existing disciplinary or cross-disciplinary knowledge, or encourage them to go beyond such knowledge and build something new, whether it be within or beyond the discipline, has a significant influence on where an inquiry is situated on the horizontal axis. For many researchers, the purest forms of IBL involve students in setting their own questions and deciding how they pursue and answer those questions. More scaffolded or directed approaches to questioning (both in terms of the setting of the question and the responsibility for determining how it is answered) might involve students identifying or engaging with questions in the 'pursuing' or 'producing' segments. Approaches which involve staff setting a question for which there is a known answer and process by which it can be discovered might sit in the 'identifying' sector.

Choi et al (2005) posit that although higher order questions potentially serve a critical role in helping learners to extend their thinking, they are more difficult to master and may require more knowledge on the part of the questioner. These findings are reiterated by other researchers (Hakkarainen and Sintonen, 2002; Abrandt Dahlgren and Öberg, 2001: 273, 279-80). This suggests that a range of different types of questions are necessary to bring about meaningful student learning and that variation between types of scenario and student methods of engagement with them are important for generating different kinds of questions and broadening students' questioning skills. Different support strategies are required not only to increase the quality and quantity of student questions, but also to increase their awareness of and ability in asking different sorts of questions.

There is a widespread recognition that one of the reasons that PBL, like other forms of active learning such as IBL, increases students' motivation to learn is that they have greater control over the learning process than would normally occur (Loyens at al, 2008). It has been proposed that particularly powerful triggers to student learning and questioning in PBL are scenarios that are '*provocative* or evoked *emotional involvement*, for instance, by containing a certain opinion or some kind of contrast or tension' (emphasis is authors' own; Abrandt Dahlgren and Öberg, 2001, 278). Edelson et al. (1999) describe this kind of activity as a 'hook', specifically designed to create interest in the question or controversy. This would clearly fit the imperative, observed earlier, for inquiry questions to be

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'authentic' or of personal relevance to the students. Another method which has been employed to encourage students to recognise that questions sit at the centre of their inquiries has been to establish a 'course' or 'central' question, which is used to focus student inquiries inside and outside of class (see: Stafford, 2008 for an example from Psychology; Justice et al, 2007 for an example from the social sciences). This approach has the benefit of providing a base to which discussion and/ or research could return if it began to lack clarity. In addition, it could also be used to set priorities, to enable students to decide what to research and what was not relevant (or less relevant). Although the course question can be established (either by students or teachers) at the start of the inquiry process, it is important that time is devoted in subsequent classes to discussion of the course question in order to engage the students with it further. A key discussion point could be: 'Why is this question important?' (Justice et al, 2007, p. 205).

The inquiry topic is also crucial to the success of inquiry activities and attempts to encourage students to generate their own questions. Students may be especially motivated and stimulated by sparking their curiosity and personal engagement, which can be achieved by, for example, confronting students with a state of perplexity so that they are motivated to seek questions and evidence to help them to resolve the problem (or question). Students can also be presented with (or encouraged to develop) questions which are personally relevant and useful, especially to their local community (Marbach-Ad and Sokolove, 2000). In their research methods classes, Crull and Collins (2004) encourage students to develop research questions of personal interest. In another relevant intervention, students are given access to practitioners and service users, provided with additional information by tutors and informed about appropriate theoretical frameworks within which to situate their new understandings. This is intended to develop students' abilities to ask questions and to identify information needs within the context of a topic that was of relevance to their professional practice (Plowright and Watkins, 2004).

Inquiry	Discipline	Reference(s)
Students engage in a collaborative research activity that is designed to guide them through the entire inquiry process, from the generation of 'a valid, practical and worthwhile research question through to presenting findings at a research 'mini-conference''.	Information Studies	Cox et al., 2008, p. 9
Students work in groups on research questions shaped by faculty research interests and questions posed by students from previous years	Mathematics	Healey & Jenkins, 2009
Students attend a residential fieldtrip where they learn to question ecological patterns and processes. They then work with one or two peers to generate a research question. Field data was gathered on the trip and analyses were carried out once they had returned to campus.	Ecology	Spronken-Smith & Walker, 2010
Students from different disciplines collaborate to develop questions that address the following scenario: 'Do something/ anything that promotes social justice and/or peace in the world. The accent in this assignment is on the action. You must use a formal engineering design methodology in the accomplishment of this task.'	Engineering and others	Matthew & Pritchard, 2009

Figure 5: Examples of inquiry activities designed to develop questioning skills

The appendix to this literature review lays out a number of the question taxonomies which have been identified through research into student questioning. A number of the studies which have been reviewed here suggest that in order to develop students' awareness of their questioning skills they should be presented with such taxonomies and engaged in activities which encourage them to think about their own questioning strategies. The consequence of this, it is argued, is that students reflect on and ultimately improve their questioning skills (Schell, 1998; Marbach-Ad and Sokolove, 2000; Hakkarainen and Sintonen, 2002).

Other approaches have been adopted to provide a starting point for student engagement with inquiry questions. Some are more teacher-led, while others are strongly student-led. Guided questioning, whereby strategic questions follow the problem-solving process, for example, could be provided to support students – individually or collaboratively – through the question generation process (Schell, 1998). Students could be allowed to choose from a range of topics from which to develop their questions rather than being provided with topics and/or questions themselves (Memory et al, 2004). Alternatively, students could be presented with a series of smaller activities or inquiries which enable them to build up to addressing the larger course question. In another example, Geography students interview members of academic staff in their departments about their research and views on contemporary geography (Jenkins, 2002).

Activities for process support: integration, iteration, reflection and secondary questions

Process support activities are those activities which may be built into an inquiry course to support student engagement with the process of their inquiry-based learning. For example, students may receive training to develop their information literacy capabilities to prepare them for the types of research that they will have to conduct as part of the inquiry. As was noted at the start of this section, there is a certain amount of overlap between the different categories that are being used and some of the process support activities described here could easily be reconfigured as inquiries that structure an entire course or as mini-inquiries that take up an individual teaching session (or a small part thereof). In the following paragraphs, we offer some general thoughts on what process support activities might be relevant in a course that seeks to promote student questioning.

By providing more opportunities for students to ask questions we might expect that they would become inculcated into a culture of questioning; and indeed this is an approach which has been adopted in some cases. However, a study by Choi et al (2005) revealed that although scaffolding of peer-questioning did result in an increased incidence of student generated questions, this did not necessarily impact positively on the quality of questions. It is therefore necessary to think about ways in which we can improve not only the quantity, but also the quality of student generated questions.

Integration of questioning into the course as a whole is important if optimal engagement with questioning (and inquiry) is to be achieved. Justice et al (2007) report the development and implementation of an inquiry course for first year social science students that aimed to encourage students to emerge from the course with the ability to approach their studies holistically and think critically and deeply about the creation of knowledge. By designing and integrating specific learning activities into an inquiry-based learning process Justice et al (2007) were able to support the development of students' questioning skills. These skills included choosing a topic, developing specific questions to underpin inquiries, and refining research questions in response to information that was encountered during the research process.
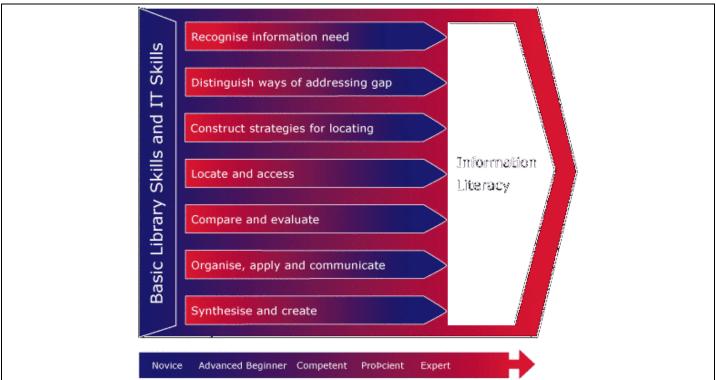
One way in which this could be achieved is by encouraging iteration of questions: so, rather than asking more questions, perhaps we should be getting students to focus on reflecting on and developing their original questions (Alberta Learning, 2004; White & Frederiksen, 1998). A similar point is made by Hutchings, when discussing the relationship between research and IBL:

> 'They are about questioning, seeking, circling. They are about repeatedly returning to the question we began with, now (we hope) informed and illuminated afresh by new learning, but always initiating new enquiries.' (Hutchings, 2007a, p. 21)

Crull and Collins (2004), likewise, suggest that by repeating research activities we can develop students' research skills, adding that a degree of progression could be introduced by repeating earlier activities in later projects. Another suggested approach is to teach students to ask questions throughout the inquiry process, e.g. of the sources consulted during research phases and of the original questions during other phases of the inquiry – reporting, sharing, presenting – with particular attention being given to how they impact on the original question(s) (Alberta Learning, 2004). Students could also be encouraged to explore their overall topic/ question from a variety of different perspectives (Alberta Learning, 2004).

Very closely linked to these possible approaches to question development is the need to provide opportunities for students to reflect on their answer to their original question and the process by which they arrived at that answer (Wyatt, 2005), beginning at the very start with the process of question generation itself and the issue of why they selected their original question (Alberta Learning, 2004). It is particularly important to note that the research/ information retrieval stage of the inquiry process is central to the refining of questions: 'when students determine what sort of information might help them to answer a question, they gain insight into how to improve the question' (Justice et al, 2004, p. 204). The setting of questions and subsequent iterative reflection is therefore important for the development of information literacy skills. In the UK, SCONUL (the Society of College, University and National Libraries: http://www.sconul.ac.uk/) has developed the Seven Pillars model of information literacy as a conceptual device to help staff and students to understand information literacy and how it relates to their learning. What is apparent from this model (represented in the diagram below) is that information literacy stands at the very centre of the entire research and inquiry process; it is not simply the retrieval or communication of information.

As questioning is also integral to this process, it is worthwhile exploring how the promotion of student questioning might relate to the seven pillars of information literacy. Consideration of questions helps students to structure information gathering from the very start of their inquiries because it encourages them to address pillars one to three, the identification of an information gap and the planning of various ways to fill the gap. Student engagement in pillars four and five, the retrieval of information and its evaluation, is also relevant to the questioning issue because consideration of research questions helps students to manage their search for information and to decide on the relevance of what they find. Finally, student attainment in pillars six and seven can be modified significantly by consideration of questions: questions determine how and what is to be communicated and help the students to define the extent to which information can be synthesised. In addition, if the information literacy process is imagined as a cyclical one, then reflection on questions is a powerful way for students to be encouraged to return back to pillars one, two and three if their answers to the questions are insufficient. This should help students to recognise that research is an iterative and not a linear process. It therefore appears that questioning and information literacy are both intimately connected with each other and with the inquiry process as a whole.

Figure 7: SCONUL Seven Pillars Model for Information Literacy (Society of College, University and National Libraries; from: http://www.sconul.ac.uk/tags/information-literacy; accessed 28.07.2015)

The benefit of encouraging students to ask questions throughout the inquiry process is that it mirrors the ways in which students tend to approach larger questions. The questioning process thus comes to mirror the reflective

inquiry process as a whole. Hakkarainen and Sintonen (2002) suggest that when they are confronted by large questions, students try to find a way of breaking them down into smaller questions and thus indirectly answer the larger question via those cumulative answers. This is a technique that tutors could instruct/support students in with relative ease. Similarly, Crull and Collins (2004) posit that several smaller research projects based on student centred active learning principles may be as, if not more, effective in learning basic research methods than long, involved group or individual projects. The same may hold true for questioning activities.

There is widespread recognition that modelling, both overt and covert, is an effective way of encouraging students to ask questions (Schell, 1998). Tutors can therefore mimic the process of questioning and model the questioning behaviours which they wish to develop in students (Alberta Learning, 2004; Davis, 1994). It might also be appropriate for experienced students to model or mentor the process of questioning for their less experienced peers (cf. Kahn and O'Rourke, 2005 on preparing students for IBL). Further examples of process support activities relating to questioning are provided on the following table.

Questioning activity	Discipline	Reference(s)
Students bring questions to class that they had generated from reading at home	Biology	Marbach-Ad and Sokolove, 2000
Students end their research reports with an original question	Biology	Marbach-Ad and Sokolove, 2000
Students engage in a 'trial run'	Generic	Kahn and O'Rourke, 2005
Students collaboratively review and select 'good' or 'bad' questions (either of their own formulation or provided by the tutor)	Biology	Marbach-Ad and Sokolove, 2000
Students prepare a questioning 'checklist'	Generic	Alberta Learning, 2004
Students brainstorm possible questions, ideas and issues	Generic	Alberta Learning, 2004
Students complete an inquiry notebook, in which they organise their work, including the questions which they generate through their research	Science	Edelson et al., 1999
Students identify three decisions they have made in the previous two weeks which involved doing some research. They then have to write out the 'research questions' that they asked themselves and list the factors they took into account when addressing those questions.	Generic	Allison et al., 1996, p. 3
Students write out three 'meaningful' and three 'non-meaningful' questions. They then ask their fellow students to read the questions and tell them what kind of answers they would expect. Students reflect on the difference between what they expected and what their peers came up with.	Generic	Allison et al., 1996, pp. 4-5
Students pose questions based on the lectures they have received or seminars they have attended. This could be done either through a physical 'question box' or online, through the institution's e-learning platform.	Chemistry	Pedrosa de Jesus & Coelho Moreira, 2009
Students spend two weeks at the start of the module on a small-scale collaborative inquiry exercise designed to model the entire research process.	Information Studies	Cox et al., 2008
Students are offered introductory readings about 'doing research' and given access to alternative models of the research process.	Information Studies	Cox et al., 2008
Students post formal questions and answers about one another's work after having conducted individual research into a specific topic of interest. This counts for 5% of the module assessment)	Bioscience	Healey & Jenkins, 2009

Students make observations in a botanical garden, come up with ten questions each, share one of them with another group, come up with a hypothesis based on the question (as a group), think up ways of testing the hypothesis, and write up (individually) their ten questions and hypothesis as a mini proposal for a research project.	Plant Biology	Healey & Jenkins, 2009
Students have to devise a question and email it to the author of an international journal article.	Structural Geology	Healey & Jenkins, 2009
In seminars students work through a series of progressive exercises on questioning. The exercises are designed to develop reflective awareness of the nature of questioning and its role in the discipline.	Theology and Religious Studies	Crosby, Pattison & Skilton, 2002

Tutoring and facilitation approach

If teachers want to encourage student questioning on inquiry courses, it is vital for them to develop students' understanding of the process, preferably from the outset because

> 'Without learning an inquiry process, students often develop a very limited and narrow view of inquiry. They may think that inquiry is finding the answer to other people's questions for the satisfaction of their teacher, rather than understanding inquiry as the process of being puzzled about something, generating their own questions and using information to satisfy their own interests and to develop their own knowledge.' (Alberta Learning, 2004)

Jenkins (2002) emphasizes the need to create curricular space for connections to occur between students and the teacher as researcher at an early stage. In terms of questioning, this could be accomplished via a number of means. For example, during classes the instructor could discuss with the class what they considered to be good questions, bring examples of types of (good) questions, or students could be asked to work together to rate their own questions (Marbach-Ad and Sokolove, 2000).

Brew (2006) emphasises the importance of language and communication in inducting students into a community in which they are seen as co-creators in the production of research:

> 'In discussing and agreeing the research questions and directions, one's language has to be tempered to address the students as junior collaborating colleagues rather than as student employees or helpers.' (Brew, 2006: p. 94)

An obvious method of supporting students in their questioning is to provide them with specific guidance (verbal or written) concerning the context and content of the activities in which they are being asked to engage. Indeed, several of the modes of scaffolding that have already been elucidated either implicitly or explicitly require that some sort of guidance be given to students to promote participation. Kahn and O'Rourke (2005) advise the provision of written or web-based support materials for the students engaged in IBL. Wyatt (2005) advocates a stepped approach to scaffolding: students are given a framework for their original experiments, but asked to bring their own questions and working hypotheses to class. The effects of such support can be positive. Students who used the online guidance which was provided by Choi et al (2005) perceived that it made asking questions easier for them: they could ask more questions; it also helped them to improve the quality of their questions and refine questions which might have been difficult to formulate otherwise. Online guidance also served as a starting point when students were having trouble generating questions.

Another facilitative approach which has been shown to benefit student questioning is the use of peer support (or collaborative questioning). Schell (1998) proposes that small groups, in which students and tutors are familiar with each other, are best for promoting student questioning. This proposition is supported by a wide range of other commentators (Plowright and Watkins, 2004; Memory et al, 2004; Wyatt, 2005). Marbach-Ad and Sokolove (2000), for example, report that student questions were often used to initiate small group learning exercises and/or to launch whole class considerations of key learning concepts and objectives. Peer-generated adaptive questioning has been shown to play a critical role in facilitating learner reflection and knowledge reconstruction in online small group discussion, with student interviews revealing that those students who felt that peer questions demonstrated their own lack of knowledge were encouraged to reflect and think intensively about the topic (Choi et al, 2005). In the

classroom or online, tutors should encourage listening and respect for others' comments and questions if they are to create an atmosphere in which questioning can flourish (Schell, 1998). Collaborative or peer questioning should therefore be considered as a powerful potential scaffolding mechanism for IBL questioning.

Assessing questions

We are used to assessing the quality of students' answers, but what about the questions they pose? If we are to encourage students to ask more questions and to move the development of questioning skills to a more prominent place in courses, this raises the issue of assessing the activities in which students are engaged and the products which they create. Indeed, assessment itself can prove a motivation towards the development of questioning behaviours. Choi et al (2005) suggest that students could be more directly confronted with the questioning process by making more explicit connections between grading and learning outcomes and the quality and type of student questioning, while Davis (1994) states that incentivisation through assessment may also have a beneficial impact on student engagement in questioning. Stafford (2008) encouraged question-asking amongst his MSc cohort in Psychology by assessing student generated questions during or after each lecture. The quality of the question was not assessed as the objective was to encourage students to ask questions in the first place; students were awarded a token amount of credit for simply asking a question. In addition, the students were made aware of the exam questions in advance of the assessment, which had the benefit of (a) making the assessment transparent and (b) emphasising to students that they could not only gain marks for knowing the correct set answer, but would gain credit for articulating an answer to the question that encompassed an awareness of the topic and the questions it raises (Stafford, 2008). Stafford (2008, p. 3) argues that 'when assessment questions are known in advance, this legitimises student questioning of the lecturer during class'. If students are asked to engage in question-asking for formative assessment, it is important that their summative assessments are aligned with this and also assign marks for successful question-asking (Pedrosa de Jesus & Coelho Moreira, 2009). Cox et al. (2008) describe how they collaborated with their first year Information Studies students to devise the marking criteria for the research posters which made up the assessment for their IBL module and included student-generated research questions.

The issue of feedback connects closely with that of assessment and should also be considered when students are being encouraged to develop their questioning capabilities. Choi et al (2005) propose that it would be useful to establish adaptive and dynamic forms of scaffolding, where students can be more directly confronted by their questioning processes and thus encouraged to reflect and refine their techniques. This could be accomplished, for example, by instructor and student modelling of questioning, by providing more direct feedback from instructors (or fellow students) about the nature and quality of student questioning strategies. It is important to note that in order to respond to student questions effectively in class, the teacher must become skilled at adjusting their approach 'on the fly' (Schell, 1998). The same holds true for fellow students: if they are to be engaged in peer support for questioning then appropriate 'process support' (https://www.shef.ac.uk/ibl/resources/sheffieldcompanion) activities should be provided in order to prepare them for the experience.

Conclusions

In this paper we have reviewed the literature on the role of questions and questioning in inquiry-based learning and made some suggestions about how these theoretical observations might be related to practical pedagogic contexts. We suggest that questions should be considered as standing at the very heart of the inquiry process and that students be given specific support and instruction in the development of their questioning skills, from the very start of their studies at university. Questioning in general, and inquiry questioning in particular, is thought to have the potential to develop a very wide range of capabilities, knowledge and attitudes in students. Perhaps most importantly, this includes the ability and willingness to ask questions of the world in which they live and thus to respond and adapt to changes that may occur in the future: to ask and answer new questions and challenges.

Overwhelmingly, the literature on IBL, and on questioning more generally, suggests that questions should be authentic and preferably formulated by the students themselves for maximum engagement and learning to occur, and this may be one of the reasons why questioning is well aligned to preparing students for life after university. Interestingly, although student level and discipline may be important factors that impact on teachers' willingness to adopt inquiry questioning pedagogies, the literature suggests that variations in the level of the students and their

discipline may not actually be that significant in their ability and openness to engagement in setting their own questions and to the positive impacts of such approaches.

Importantly, we posit that the frequent conflation of inquiry- and problem-based learning may be misleading on the issue of questioning and not-very-helpful to thinking about either approach. While at the boundaries of both pedagogies there is a great deal of overlap between IBL and PBL, this may be a barrier to understanding. For us, the key difference is that IBL focusses on students addressing a question which leads to some form of inquiry. Preferably, the students will have established the question for themselves and there may not be a single known (or knowable) answer to the question. Similarly, the process by which the students engage with this question will ideally be determined by the students themselves, although their engagement in the process should be supported by the tutor.

Our review ended with reflection on the issue of 'design for learning' through the use of a conceptual framework that we developed at the University of Sheffield (https://www.shef.ac.uk/ibl). We strongly recommend that practitioners intending to adopt an inquiry-based approach focussed on questioning consider how it might be fully integrated into their course(s) from the design stage. This means bearing in mind how every aspect of the course relates to inquiry and questioning, from the information that students are given to help them to engage in their inquiries, through the various learning activities that they are expected to participate in, to the assessments that they have to perform, and the approach that the tutor adopts in supporting them.

Questioning, therefore, stands at the very heart of the inquiry process and indeed may be its main distinguishing feature from other pedagogies in Higher Education. Questioning forms an integral part of the skill-set that students require for successful lifelong learning. However, in order to provide students with the opportunities to engage in inquiry questioning and to develop their capabilities and disposition towards inquiry, educators must be far more thoughtful and holistic when designing curricula. This paper will hopefully provide a useful starting-point for some, although we have no doubt that it raises more questions than it solves.

Appendix: Some questioning taxonomies

1. Marbach-Ad and Sokolove, 2000

Marbach-Ad and Sokolove (2000) recommend that students are presented with the taxonomy at the *beginning* of the semester so that they know what is expected. The presentation of the taxonomy to students in both traditional and active-learning cohorts was reported as impacting positively on the quality of the questions which they asked, although to a greater degree with those students following an active learning approach.

- **Category 0**: Questions that do not make logical or grammatical sense, or are based on a basic misunderstanding or misconception, or do not fit in any other category. (This is a 'catch all' category that instructors can readily subdivide for teaching purposes – for example, when grading written questions. In this case we chose not to subdivide the category in order to focus on the characteristics of desirable questions.)
- **Category 1a**: Questions about a simple definition, concept, or fact that could be looked up in the textbook (i.e., 'what is meant by the polarity of the membrane?').
- **Category 1b**: Questions about a more complex definition, concept, or fact explained fully in the textbook (i.e., 'what does it mean when it is says air moves through a bird's lungs?').
- **Category 2**: Ethical, moral, philosophical, or sociopolitical questions (i.e., 'carbon monoxide is a very deadly gas binding to hemoglobin much faster than oxygen. If it is so deadly, why are there no carbon monoxide detectors throughout the dorm halls?').
- **Category 3**: Questions for which the answer is a functional or evolutionary explanation. (In this case students begin by asking a question that relates to function and could, in principle, be answered in functional terms – 'Why do people have an appendix' – however, the deeper answer is more often related to evolution than to function (the human appendix is a vestigial organ)).
- **Category 4**: Questions in which the student seeks more information than is available in the textbook (i.e., 'what causes the 'rumbling' in your stomach when you are hungry?').
- **Category 5**: Questions resulting from extended thought and synthesis of prior knowledge and information, often preceded by a summary, a paradox, or something puzzling. (i.e., 'In chapter 35 it says that caffeine, if taken

excessively, can disrupt motor coordination and mental coherence which can cause depression. I known that Coca-Cola has some amount of caffeine in it. Does this mean that excessive consumption of it could lead to depression...?')

- **Category 6**: Questions that contain within them the kernel of a research hypothesis (i.e., 'I have heard that some people snore so badly that they stop breathing during their sleep. What correlation is there, if any, between 'heavy snorers' and a higher instance of apnea during REM sleep. Can the attention their nervous system is devoting to a dream, interfere the regulation of respiration?').

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2. Hakkarainen & Sintonen, 2002

Interrogative model (I-Model); there are two types of questions in the model:

- **Initial big questions:** serve to define the goal of inquiry, expressed as propositional ('Is B the case or not?') or wh-questions ('Where (who etc.) is B?') or explanation-seeking how- and why-questions ('How does B work?', 'Why does B occur in circumstances C?'). These initial questions involve large theory claims. The inquirer therefore tries to find an *indirect* way of constructing an answer by formulating a series of small questions, and by attempting to derive an answer to the initial question from these.
- **Series of smaller questions:** the inquirer attempts to find – or rather, construe – an answer to the initial big question by seeking answers to her or his small questions, answers which the inquirer then can draw on in the interrogative derivation of the chosen conclusion.

There are distinctions between the different types of questions:

- **Yes/No questions:** there are only two alternative answers; the most restrictive kinds of answers
- **Wh-questions**, in turn, take individual terms as answers. Here the inquirer knows that the answer is of a particular type and must, e.g., mention a person (who?), location (where?) or some such individual to count as an answer at all.
- Why- and how questions (as well as covert explanation-seeking or some category-requiring questions like 'What is the reason for B's being a C') are even looser still: sometimes the questioner literally does not know what type of an answer would count as appropriate.

Why and *how* questions are typical explanation-seeking questions and cannot be satisfactorily answered without elaborating an explanation. In many cases also *what* questions require articulation of explanation; e.g., 'what are the reasons for gravity?' or 'what is inside of a battery?' *Wh*-questions (i.e., *who, where, when*, and *how many* questions) were considered to represent fact-seeking questions that can be answered by providing factual information.

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3. Abrandt Dahlgren and Öberg, 2001

Context: environmental science PBL programme

- **Encyclopaedic questions** – these are questions which are formulated in such a way as to suggest that the students are expecting 'to find an unambiguous and not too complex answer'. They are characterised by their uni-dimensionality as they contain only one aspect which is often quantitative.
- **Meaning-oriented questions** – these kinds of questions aim to find 'phenomenological meaning of certain terms or concepts', which are 'often problematised in relation to other terms'.
- **Relational questions** – contain more than one aspect and the relationship between these aspects, often aiming to explain causes or understanding the consequences of a certain phenomenon.
- **Value-oriented questions** – these types of questions are comparative in nature, aiming to evaluate phenomena in terms of improvement or degradation. Students search for norms on which to base judgements, although it is clear that the students do not expect to find definitive or pre-eminent norms.
- **Solution-oriented questions** – focus on the management of environmental issues rather than the search for the meaning of different aspects of these problems. Questions typically deal with large and complex problems on an abstract level and students seem to look for concrete solutions.

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4. Chin et al (2002)

Two main types of student-generated questions were identified:

- **Basic information questions** comprised factual and procedural questions.

- **Wonderment questions** were pitched at a conceptually higher level and included comprehension, prediction, anomaly detection, application and planning or strategy questions.

Five issues regarding student-generated questioning:
- Asking wonderment questions is manifestation of the use of deep processing strategies and reflective of a deep approach to learning;
- Students asked mainly procedural questions when assigned tasks required them to follow given instructions and step-by-step procedures; this did not engage them at high cognitive levels; the implication is that the nature of the tasks that teachers set and the cognitive demands required from the students influence the types of questions that students ask and thus, to some extent, the learning approach and the learning strategies that they adopt;
- Asking wonderment questions can stimulate either the questioners themselves or another student to generate an answer, bringing to the fore other deep learning strategies which have hitherto been latent, and potentially leading to talk at a higher conceptual level;
- Students did not always ask wonderment questions spontaneously. Such questions, if addressed, can help students to clarify their doubts and advance their conceptual understanding. This suggests that unless students are stimulated to think about such questions, many students would not ask them. The implication is that teachers cannot fully rely on students' spontaneous questioning and must explicitly orient their students towards asking questions, e.g., by specifically encouraging them to generate questions, either verbally or written;
- Even the students who did not spontaneously ask higher-level wonderment questions were capable of asking thoughtful questions about things that puzzled them or which they would like to know more about. This suggests that teachers could explicitly encourage such students to ask questions by providing extra opportunities for them to do so.

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5. Choi et al (2005)
Context: online peer-questioning support framework. Effective types of questions should be questions that:
- **Clarification or elaboration questions:** seek missing information from learners' explanations
- **Counter-arguments:** contradict learners' opinions
- **Context- or perspective-oriented questions:** More systemic questions that prompt learners to consider various contexts and perspectives for each problem

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