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Abstract: Higher education institutions are currently undertaking a challenging process in moving from teacher-orientated to student-focused approaches. Students' ability to asking questions is fundamental to developing critical reasoning, and to the process of scientific enquiry itself. Our premise is that questioning competences should become a central focus of current reforms in higher education. This study, part of a broader naturalistic research project, aims at (1) describing teachers' reactions to students' questions; (2) exploring how these reactions are perceived by students, and (3) how these two dimensions interrelate to create 'contextual questioning zones'. Specific components of a context, such as 'Settings', 'Social' and 'Individual/Personal', will be highlighted. The discussion of two 'opposite' contexts of enquiry is based on qualitative data gathered through close collaboration with four teachers of undergraduate biology at a Portuguese university. During an entire academic year these teachers were observed during their 'daily activity'. The teachers and a group of seven selected students were also interviewed at the end of the year. Discussion of the interview data, validated by the respondents, is used to illustrate the different kinds of 'questioning zones'. The paper concludes with some reflections and suggestions to promote authentic enquiry-based learning experiences.

Contexts for questioning: two zones of teaching and learning in undergraduate science

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Introduction

This paper reports on the ways university teachers react when students' ask questions, and how their students then perceive those reactions. The broad context of the work lies in improving teaching and learning in higher education, in this particular case within undergraduate sciences at a major university in Portugal. While Graesser & Person (1994) maintain it is '*well documented that student questions in the classroom are very infrequent and unsophisticated*' (p. 105), other studies indicate that learners actually *do* have questions but, in general, avoid asking them (Dillon, 1998; Teixeira-Dias, Pedrosa de Jesus, Neri de Souza & Watts, 2005). The reasons for this avoidance are complex (Watts & Pedrosa de Jesus, 2007) and largely hinge on the confidence students have that their questions will be well received and taken seriously by teachers.

So, do teachers actually welcome students' questions? Rop's (2002) work suggests that teachers are ambivalent at best, they commonly listen to a student's open curiosity with contradictory feelings: the need to 'honour' a student's question, give students time and patient support in their struggle to understand content, all of which is then weighed against the seemingly incompatible need to maximise 'teaching time' and 'cover the content of the course'. Less compassionate, though, is when teachers perceive student questions as annoying, an impediment, overbearing and a test of patience, particularly when they arrive too frequently or seem set to challenge received 'curricular wisdom'. In this paper, we are concerned with such contextual 'micro-politics' of classroom life. These impact upon the ways in which teachers either encourage or discourage the asking of questions in class time.

This paper sets out two deliberately dichotomous 'contextual zones for questioning' that we call Zone 1 and Zone 2, and draws upon literature in learner-generated questions and teaching approaches. We outline the design of the research and present some illustrative qualitative data gathered from teachers and students undertaking a semester-long module in

life sciences, on their experiences of classroom questioning. The paper concludes with reflections and suggestions on constructivist classroom contexts and cultures, and on ways that teachers can manage or, in our terms, can orchestrate learners' questioning within the flow of a session to enable authentic enquiry-based learning experiences (Watts, 2005; Watts & Pedrosa de Jesus, 2007).

Approaches to teaching

Portuguese higher education institutions are undertaking a challenging process in moving from a teacher-oriented approach to a student-focused approach (Veiga & Amaral, 2009). This greater emphasis on a learner-centred vision of university teaching demands that students' academic autonomy be the outcome of well-planned educational experiences to help all students develop independence (Biggs, 1999) and become critical questioners (Ironside, 2003). According to Chin & Osborne (2008), this ought not be unusual, instead it should be a key feature of academic scientific discourse and, from this standpoint, questioning is central to eliciting explanations, postulating theories, evaluating evidence, justifying reasoning and clarifying doubts. Thus, our central premise is that the act of questioning can lead learners to engage in critical thinking and reasoning. Given that asking questions is fundamental to science and scientific enquiry itself, the development of students' abilities to ask questions should, therefore, become a central focus of current reforms in higher education. We argue (for example, Pedrosa de Jesus, Neri de Souza, Teixeira-Dias & Watts, 2005; Watts & Pedrosa de Jesus, 2005) that question-asking is a key component to a learner's 'enculturation' into the patterns of understanding, language and thought, critique and debate that are characteristic of academic disciplines. In our view, this is maximised where university teachers create positive learning experiences, climates for questioning, the pursuing of personal interests and direction, for individual and group research projects, for collaborative

learning and the co-construction of knowledge (Pedrosa de Jesus, Almeida & Watts, 2004; Barbosa, Jofili & Watts, 2004).

There is a body of research to support the argument that most ‘teachers teach the way they learn’ (Stitt-Gohdes, 2001). Since many university teachers have experienced academic success within instructor-centred environments that relied heavily on teaching-as-lecturing, it is understandable that preferred styles of teaching, at least initially, would be to repeat ‘what worked for them.’ Typically such teachers’ behaviours would reflect the beliefs and values they hold about the learner’s role in ‘knowledge exchange’ (Heimlich & Norland, 2002), would be content-oriented and prefer to use formal teaching methods, favouring less student involvement, questioning, and more structured class activities (Hayes & Allinson, 1997; Pithers, 2001). On the other hand, classroom teachers who are skilled in principles of adult learning and have experience with student-centred learning and constructivism are more likely to adopt broader approaches to teaching (Stitt-Gohdes, Crews & McCannon, 1999). Typically, such teachers would have broad views of how teaching can occur and strong beliefs about the need to engage learners’ questioning in the learning process. They would be aware of the changing demographics of classrooms and the influence of technology on students’ ways of learning (Glenn, 2000; Stitt-Gohdes, 2003). They are more likely to substitute self-directed learning opportunities and interactive learning environments for the traditional lecture and make use of *‘varied resources to create personally meaningful educational experiences’* (Glenn, 2000, p. 14). They would have understanding of the shifting balances of authority within the classroom as students assume greater responsibility for their own learning.

Despite the general confusion in definitions of ‘teaching styles or approaches’ research (Devlin, 2006), the identification and description of relevant teacher characteristic has revealed to be useful in the effort to understand the complex dynamic of the teaching-learning

processes (Authors). In this work we used the revised Approaches to Teaching Inventory, or ATI-R (Trigwell, Prosser & Ginns, 2005) because this instrument was developed in the context of higher education. These authors have identified two opposite preferential teaching approaches: ‘information transmission, teacher-focused’ - ITTF, and ‘conceptual change student-focused’ - CCSF (Trigwell & Prosser, 2009).

[Table 1 near here]

With the permission of these authors, the ATI-R was translated to Portuguese, and then, for validation, translated back to English. The Portuguese version was posted on to the university website with an e-mail inviting all teachers, across all subject areas, to participate (n=890). Ten per cent completed the inventory and the reliability measures revealed internal consistency for both scales of the Inventory, with Cronbach alpha over 0.75. (ITTF – 0.83; CCSF – 0.86). For the purposes of this paper we focus on four lecturers who teach undergraduate microbiology and evolution, two identified as being ITTF (Teachers 1 and 2) and two as being CCSF (Teachers 3 and 4). We arrived at these designations through working closely with all four teachers during an entire school year, and through their responses to the ATI and semi-structured interviews.

The teachers and students were briefed at the beginning about the nature of the research, were therefore sensitised to the issues surrounding classroom questioning. This was conceived as ‘research into the educational experiences of students’ and not as an evaluation of the teaching – or teachers – per se, and was explained to participants as such. The four teachers with whom we worked opened their classrooms to us, gave freely of their time and opinions. The teaching of microbiology and evolution for a year-cohort (n = 160) was organised in four groups of 40 students, each group having two-hour lectures, two-hour

practical classes and a one-hour tutorial each week. Two researchers completed an observation grid of each lecture session, paying particular attention to teachers' interactions with students. All interviews were audio-taped, transcribed and coded for analysis, and took up issues flagged by interviewees in relation to the semester's teaching. For the purposes of this paper we report interviews with seven students, a volunteer subset of the students in the full cohort. Data was also collected from the university's web-based e-learning systems, used by both teachers and students, and each element of this qualitative data was validated using respondent validity in each case.

Two contextual zones

Our starting point is that the asking of questions is context dependent. In this work we are interested in creating 'contexts of questioning', to move beyond teaching style, or learning style, as the prime criteria for building an environment where students' classroom questioning is the norm. For us, a context is the set of entities that influence action in a particular setting, situation or on a specific occasion (Brezillon, 2003; 2005), in particular the 'physical, emotional, and intellectual environment that surrounds an experience and gives it meaning' (Caudron, 2000, p. 55). In this sense we (Watts, Pedrosa de Jesus, Silva Lopes, Moreira & Almeida, 2009) delineate a context as being entailed by the:

- (1) *Setting*: the broad location, the physical environment, the surroundings, the time, systems, access and availability of information, the ambiance;
- (2) *Social*: the learning community, its history, ethos, the roles, responsibilities, relationships, tasks, expectations, other people, what the participants are actually doing, their goals, the activities involved;
- (3) *Personal/Individual*: individual dispositions, skills, competencies, participants' mental and physical states, intentions, moods, engagement, expertise.

Our sense of context is *interactional*: in educational settings, in teaching and learning, context is a relational property among people, place and activities. This view argues that the scope of contextual features is defined dynamically, context is relevant to particular settings, instances of action and particular parties to that action: context and activity are not separable.

That is, context is embedded in activity and arises from it. Taking these elements one at a time:

(1) *Setting*: Clearly, a raked lecture theatre has very different environmental dynamics to a small seminar room ‘in the round’; a science lab to an art studio; a formal conference setting to an informal classroom; a PowerPoint presentation to a field-study outing (Watts & Pedrosa de Jesus, 2006). While, technically, each setting allows for questions from the ‘floor’ and answers from the ‘lectern’, some are clearly more inhibiting than others. In this work, we observed teaching and learning in a mix of university science lecture theatres, teaching laboratories and tutorial rooms. Setting also relates to the ‘pace, space and place’ (Coole & Watts, 2009) of teaching, learning and question-asking. Question-asking changed quite noticeably, for example, when students had the opportunity to ask questions in small tutorial groups, individually or by email. In the latter case, they could ask when the time was ripe for them, in the middle of an assignment, in the middle of the library and/ or in the middle of the night (Pedrosa de Jesus *et al.*, 2005).

(2) *Social*: While some teachers work from the basis of either personal and/ or institutional authority and control, others operate from a basis of co-constructing knowledge with students (Barbosa *et al.*, 2004). On one hand, a teacher’s authority can transcend an ‘expert-novice’ divide to be a clear power hierarchy, particularly so, for example, when the teacher operates against institutional assessment procedures, ‘teaches to the test’. On the other, this social dimension suggests how interactions between students can be encouraged, maximised: where discussion clusters are used, small-group work or project teams organised.

A social context is also task-dependent. To listen and take notes in lecture mode is different to working at small-group mini-projects; engaging in text-based coursework is different to making a presentation to a class of peers; undertaking a laboratory practical assignment is different to conducting off-site fieldwork. In each of these, the ‘relational formality’ between teacher and taught, and also between students, is different and provides different task-contexts in which student’s questions can flourish or not.

(3) *Personal/ Individual*: As discussed above, teachers can be seen to have discernible styles of teaching. From Trigwell and co-workers studies, we have attributed to their teaching approaches the propensity to encourage student questioning (Pedrosa de Jesus, Lopes & Watts, 2008). In addition, (in Pedrosa *et al.*, (2005) we show that some students have a greater disposition to questioning than others, and that this can depend on the means by which they can ask questions (orally in class, in writing during sessions, by email at any time and place, through web-based ‘chat’ forums). So, it is not just the teaching style that matters, but also the students’ learning styles and questioning styles.

Two polarised contextual zones: high formality and low conformity

To polarise the extremities of the discussion so far, to sharpen contrasts, we have used the expressions Zone 1 (a high-formality context) and Zone 2 (a low-conformity context), as described below. Our intention is not dissimilar to Vygotsky’s (1978): the two zones indicate the ‘authoritative-pedagogic distance between teacher and taught’ related, in this instance, to the teachers’ use of a range of approaches to teaching, and their ease or unease with students’ interactions and contributions through questioning. We introduce some of the teacher and student interview data and our intention is to use this as illustrative of the two contextual question zones, rather than categorise and classify student or teacher talk.

Zone 1: From our perspective, Zone 1 tends to be dominated by a traditional ethos: formal lectures, prescribed laboratory sessions, structured tutorials, and teacher-dominated questioning. It is through direct and indirect questioning that the authoritative expert manages the zone. By definition, this high-formality zone has an unequal relationship at its core because it is the teachers, as the authoritative experts, who hold access to knowledge. Learners can ask questions but, as much research has pointed out, when these do occur, learners' questions tend to be infrequent, fairly routine and information-seeking (Walsh & Sattes, 2005). Teachers direct the level at which they accept questions, offer their knowledge and adhere to outcomes and achievement, to the levels and standards against which they are operating.

[Table 2 near here]

Zone 2: This is a low conformity context, related to more devolved 'pedagogic authority'. It is largely learner-focussed, de-emphasising any 'epistemological distance' between experts and novices in relation to their knowledge and abilities: there is a greater sense of students as intellectual colleagues. Teaching strategies vary: 'low-formality' lectures small group work, problem-based learning and use of on-line learning systems. Students tend to operate in groups or 'learning sets' and work as near-contemporaries; teachers have collectivist or constructivist societal views of the distance between the cultural orthodoxy of particular knowledge. Groups are usually established at the outset by the teacher or through informal means, with more-or-less equal power between members, the learners being inter-dependent. This means that authority is either rotated on some basis, or shared between group members.

A Zone 2 context is where learners are in a conducive social context in which demonstrably original and creative activities are rewarded with low fear of failure. It fosters original and unexpected thinking, questions that may otherwise be 'disruptive' of routine,

class control, orderliness, organisation, curriculum orthodoxy. Zone 2 can be described in constructivist terms as ‘communal constructivism’ (Barbosa *et al.*, 2004; Holmes & Gardner, 2006). In the main, it is where the outcomes of learning are negotiated, shared and distributed, both teachers and taught prompt, provide and role model ‘creative questioning’.

[Table 3 near here]

In the next section we illustrate these two zones through the interview data, exploring both teachers’ and students’ experience and perceptions of the sessions across one academic year.

Zone 1: a context of high formality

One teacher we interviewed [Teacher 1 - ITTF], a well-established microbiologist, discussed her reaction to students’ questions:

Normally I provide some form of answer. When I know it, I answer. When I don’t know... well I give the bits I do know from within the whole question. For the more specific parts of the question, I would say [to the student] that I have to do some research first... that I will try to know and that I will give the answer next time. Or I suggest that they talk to me at the end of the class. But probably, if the question is related to the content of the lecture, I am prepared to give an answer.

This is the essence of Zone 1, it is the teacher who decides whether and how to provide social support and guidance, how much and to what ends, what support and guidance is needed for the learner to gain in competence. In such a high-formality zone, teachers make the decisions about the level of the learner and the standards of learning to be reached, what the learner needs, what questioning is possible, what actions are required and the timescales involved. A second lecturer, Teacher 2 (ITTF), has a similar approach:

I try to answer... because those students that ask questions are the ones that have concentrated most on the class. They are the ones that have their studies more developed... the ones that are most interested. And, by answering them, I think that I am also helping the others. I think that I always tried to answer.

On the other hand, Teacher 4 (CCSF) is somewhat scathing of this ‘Zone 1’ approach.

He calls it ‘classical teacher reasoning’, which he describes as:

Afraid of losing authority... but I think that is absurd... though I think that some people feel like this. It produces very unidirectional communication... the students ask, and the teacher simply gives a straight answer or ignores the question. That is the reasoning that prevails... it goes in one direction, showing who has the authority. But it might not be just an authority thing... maybe that [kind of] teacher just wants to end the ‘incident’ [the student’s question] and continue with ‘content transmission’.

Overwhelmingly, the students interviewed saw this mode of teaching, the tone of lectures, the authoritarian stance (*personal disposition*) of the teacher, to be inhibitive of questioning, affecting their own disposition for posing questions during class:

I didn’t ask any questions because I didn’t want to interrupt the rhythm of teacher’s talk.
(Filipe)

Sometimes the teachers’ answers discourage students’ questions because he doesn’t answer directly... he explains diverse topics before he gets to the answer that really matters to us... I still prefer asking questions orally, however I actually questioned less in this semester when compared to the last one, because the situations were so different... (Lia).

Moreover, other relational aspects of the (*social*) context, aside from ‘teacher type’, influenced their questioning, as Sofia mentioned:

Being in the same class with older students make us feel uncomfortable about asking questions.

In some Zone 1 lectures, the physical conditions (*setting*) were not suitable for creating what we would call a ‘question-based learning environment’:

The room didn’t help; we couldn’t even see the teacher - or the slides, for that matter!
(Manuela)

I don’t think the teacher could have done it any another way... But it was really monotonous, there was too much content to be covered and no space for a question, no break, we just wanted to speed it up, get it over with! (Cátia)

The Zone 1 tasks in this instance were commonly the traditional format of lectures and note-taking, test-based teacher questioning, standard laboratory procedures. Similarly, the space and time of activities both influenced students’ questioning. These Zone 1 systems tended to conform to traditional scheduled events, regular classes, timetabled tutorials

etcetera. This is characterised by an exam-oriented context, indicated by Teacher 1's (ITTF) comments on student behaviour on the eve of tests:

During the semester they [students] don't study. Perhaps about three days before the exam they'll attend tutorials. And they come precisely because they haven't studied before. They'll attend those tutorials on the eve of the test to hear the questions of their colleagues and to hear how we [teachers] answer. They want to know the doubts of their colleagues, those that have studied... They come with the hope that the teacher will reveal something about the test.

Zone 2: A context of low-conformity

When Teacher 3 (CCSF) was asked how he reacted to students' questions, he said:

I love it! And I have absolutely no problem in saying that I don't know the answers. That's the first thing... Obviously I don't know the answer to everything [laughs]. I think it is very important that they put questions out there. I try to get their classmates to answer the question instead of me. I really make an effort to be the last one to say anything... I try to synthesize at the end of a discussion and to correct what was not quite correct. But, I think that students' question are very important. And I get really excited when that happens... when they interrupt the lecture and ask a question. I think that is extremely useful... I can't conceive of teaching in any other way.

Similarly, Teacher 4 (CCSF) was also enthusiastic about students' questioning:

If students participate more in lecture then they would be less dependent on the teacher's voice. Actually, I think it would take less time to prepare the lecture itself. And, that way, the lectures would work more according to students' needs... especially if the teachers are not afraid, to assume that they don't know if someone asks them a question. For example, for myself, after so many years, I know quite a lot of microbiology...but there are still many questions to which I don't have an answer. I think there are many teachers that are afraid of that... so they invest a lot of time in heavily structuring the lesson.

The ways that teachers react and deal with students' questions is important, emphasising a collaborative dynamic between staff and students. The following two students had been part of sessions that were openly question-based, where the strategy to involve students individually in the practice of enquiry had been developed across the academic year. The teacher's disposition (*personal*) towards enhancing students' own questioning was highly valued:

We have ended up developing a real willingness to ask questions, because the teacher has made us feel free and comfortable in doing so... The fact that the teacher stimulates our questions has even helped us in other disciplines and with other teachers. (Filipe talking about teacher 3)

Yes, I feel really free to ask questions because the teacher is always ready to answer them... I recognise that he feels comfortable about answering our questions. And that's important for us, we students, to feel that motivation. (Ana talking about teacher 4)

Zone 2 is made facilitative and conducive by both teachers' and students' willingness to engage in questioning:

When the situation is more interesting, we are more motivated to look for and to know why, to research. I become more curious... and I am also keen to know what kind of questions my colleagues are asking, and why they asked such questions. (Ana)

Yes, concerning the questions I've formulated, I think motivation is important... The more interesting a particular situation is made for each person, then the more involvement will be created and more questions will be raised. (Lia)

In the following example, a 'Zone 2' enquiry-based context was created using the university's web-based 'Question Forum'. This example, in this case about evolution, is characterised by our sense of social co-construction of knowledge. Students were challenged by an initially controversial statement written into the Question Forum by Teacher 3, and were then asked to formulate questions and develop arguments that supported their opinions on the topics being discussed. Teacher 3 only contributed to the discussion when he felt it was appropriate to prompt discussion or give feedback. As an (*social context*) example, a truncated version of students' and teacher written interactions in the forum is as follows:

This discussion about human evolution is causing a lot of controversy not only in this forum but also in my own thinking. Sometimes, I just start agreeing with some of the opinions I read, but suddenly these ideas seem so controversial that I can't stop questioning myself. I have already referred to this, but I have to reinforce it again: Is it plausible to talk about evolutionary mechanisms in humans?! Is it possible to apply to our own species this panoply of terms that humans themselves have idealised for describing other species? Don't you think that rationality could be a factor that makes us one great exception to evolution? Shouldn't we question ourselves about the evolution of human species when all terms created /used were idealised for other species? (Maria)

I'm writing this comment here because I consider that Maria has opened up a 'window' of discussion that nobody has taken up. To those that consider that comments are always around the same topic, here we have a good opportunity to 'deviate'. (Teacher 3, after several other students' interventions)

In relation to the question you have asked, Maria (...) I think we have already 'overcome natural selection' and that sexual selection is not a term that can be applied to us, we have to adapt terms; 'cultural evolution' can be fully applied to human beings as well as the concept of 'meme' referred in previous comments. Presently, human beings, instead of being driven by

Darwinian evolution, in some cases hide their genes and show the extreme power of cultural heritage. (Nuno)

I have been reading some comments to my last post, and I think that - eventually - my idea was transmitted in a wrong way. I'm only arguing that the disadvantages, by fact of being rational, sometimes outweigh the advantages, and that makes me reflect a lot about it. However, I'm really trying to reinforce my disagreement with the terms 'Evolution' and 'Sexual Selection' when applied directly to our own species. (Maria)

Teacher 3 commented on the benefits of these 'Zone 2' exchanges for student learning:

In my opinion, the online forum is a very useful strategy in many aspects. First, as a teacher, it is a way to stay in contact with the students beyond the classroom. We get closer to the students. At the end, our discussion had many jokes to 'lighten' up the environment. I think that this kind of situation, between teachers and students, is very rare. In my opinion, this motivates students... On the other hand, the online discussion creates a 'chain' among them. They think "Ok. He answered... I will answer too." So, the majority of the students are connected through this online discussion and this is a great motivator.

This was a view shared by students. They considered the use of the Question Forum in their sessions, to be very positive:

It's very important, especially when we are studying at home. It's a means by which we can have the teacher available at almost any time. Also, before the tests, I usually like to see the questions from my colleagues and the teacher's answers because sometimes those will also be the answers to some of my own questions. (Patricia)

At least, while we are studying, we have this facility; otherwise we would have to keep contacting the teacher... Also, I think it is useful for those persons who are shy and for those who haven't the capacity and time for formulating questions during classes. (Cátia)

Teacher 3 further emphasised these advantages:

Due to the online forum, the students think about this theme [evolution] several times during the week. This is very useful. Because, otherwise, a student will only 'switch on' when he or she enters the classroom, and then 'switches off' once more when he leaves the class, and the discipline will probably 'die' there. And, in that case, there will be no continuity of the personal development of the student.

As well as being more personally rewarding and engaging, the Zone 2 dynamic of working in a low-hierarchical relationship between teachers and students spilled over into forms of assessment (Pedrosa & Moreira, 2009). Some students stressed the importance of being assessed through problem-based cases and online discussion forums, as a means of developing their questioning skills:

I felt an improvement throughout the year ... Practice helped us a lot, we have been training in solving those situations [problem based cases]... I think that if we continue with

this method we will be able to attain a higher level in formulating questions and answering them so that we really understand things. (Ana)

I think assessment has influenced us... We have had to pose at least two questions [as part of an online discussion forum] but I ended up generating more... The first questions I asked, I felt obliged to do so. But, actually, then other questions came out spontaneously, because we start to interact, and then it became natural! (Cátia)

Discussion

This paper addresses issues of teaching and learning in undergraduate sciences, around two broad approaches to the production and reception of students' questioning. Our two contexts of enquiry, zones 1 (high formality) and 2 (low conformity), are distinguished in terms of the physical setting, social relationships and personal dispositions. We have used these two contextual zones to characterise the ways in which students' questions are fostered and managed.

Clearly, different kinds of teaching can generate different questions. In Zone 1 traditional lectures are centred on the teacher and only few students have the inclination, skill and confidence to raise questions from the audience. The teacher dictates the forms and 'quanta' of knowledge transfer, the structure and the rhythm of the class, and this shapes teacher-student as well as student-student relationships. In Zone 2, sessions are geared to being student-centred with more opportunities for fostering and welcoming questions through problem-based learning, mini-projects and interactive online systems, alongside more traditional lecture formats. While they understood the traditions of Zone 1, the students we interviewed were overwhelmingly appreciative of a Zone 2 context, where their learning experiences were seen to be engaging and meaningful, their relationships with lecturers superior, their experiences of asking questions highly favourable. While there are obvious limitations to leaning too heavily upon the views of a self-selecting sample, we were appreciative of their open and frank comments during discussions.

Given both the broad context for change within the ‘Bologna process’ in European universities, and our own stated preferences, it is no surprise that we are advocates of Zone 2 contexts. Such ‘zones of low conformity’ are premised on the basis of broad, well-orchestrated, ‘pedagogic equity’ (Watts, 2003; Watts, 2005; Watts & Pedrosa de Jesus, 2005). We have made the argument elsewhere for a context to teaching and learning that is communally constructive (Barbosa *et al.*, 2004; Coole & Watts, 2009) - where teachers and students are not simply engaged in developing their own information but are actively involved in creating knowledge that will benefit other students and teachers. That is, together the members of the group construct new understandings, Rogoff et al., (1993, p.6) describe this as ‘*a process and system of involvement of individuals with others as they communicate and engage in shared activities*’. It moves towards a focus on transformation of learning and has, as Jordan (2004, p.42) says:

No prescribed content outcomes – the focus is on developing shared meanings / inter-subjectivity and each participant contributing to the on-going learning experiences from their own expertise and points of view.

Or, as Teacher 4 (CCSF) puts it:

There is one type of question that I don’t like at all: ‘What do we need to know?’ I actually hate that. Because, I don’t know what they have to know exactly. I don’t even know what I have to know! [laughs]. I like curiosity questions, the real ‘knowledge’ questions, questions where the students are actually developing and challenging me... even if I don’t know the answers... I have no problem at all in saying that I don’t know.

Zone 2 is, in our constructivist terms, where learners have ‘enabled curiosity’ and a contextual framework within which to ask and explore questions, and where teachers’ reactions to questions are – at the very least - constructive and welcoming. It is learner-centred, enquiry-based learning, where the learner becomes an independent questioner - with the associated power. Questions provoke thought and reflection; strong questioning skills fuel and steer the inventive process required to understand and develop something new. They are

directed towards being productive of knowledge (Holmes & Gardner 2006; Barbosa *et al.*, 2004).

While one of the driving aims of university teaching is to lead students towards the development of the abilities, confidence and opportunities required to ask questions, our research (for example, Teixeira-Dias *et al.*, 2005) indicates that a Zone 2 context for teaching and learning is not arrived at easily, but entails vision and determined hard work. By way of suggestion, we propose:

- Promoting peer discussion and debate between ‘ITTF’ and ‘CCSF’ teachers in order to try to make the ITTF teachers more sensitive to the benefits of ‘true questioning’ through the ‘perspective’ of their CCSF colleagues;
- Suggesting ‘ITTF’ teachers to observe their ‘CCSF’ colleagues;
- Suggesting that (and supporting) ‘ITTF’ teacher in their implementation of ‘simple’ strategies that can foster some student questioning. For example: asking student to write down their main issues, concerns, puzzlement of that lecture. They might then collect those questions and use them at the beginning of the next lecture.

Despite some advances, there is much work to be done to change teaching and learning in this kind of way.

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References

- Barbosa, R. Jofili, Z. & Watts, D.M. (2004). Cooperating and constructing knowledge: Case studies from Chemistry and Citizenship. *International Journal of Science Education*, 26, 8, 935-950
- Biggs, J. (1999). *Teaching for quality learning at University*. Buckingham: Open University Press.
- Brezillon, P. (2003). Using context for supporting users' efficiency. In Proceedings of 36th Hawaiian International Conference on System Sciences (HICSS'03), Track 5, 127, Hawaii: IEEE Computer Society.
- Brezillon, P. (2005) Role of context in social networks. In I. Russell & Z. Markov (Eds.) Proceedings of the 18th International Florida Artificial Intelligence Research Society (FLAIRS), 20-25, Florida: AAAI Press.
- Caudron, S. (2000). Learners Speak Out. What Actual Learners Actually Think of Actual Training. *Training and Development*, 54, 4, 52-57.
- Chin, C. & Osborne, J. (2008). Students' questions: a potential resource for teaching and learning science. *Studies in Science Education*, 44, 1, 1-39.
- Coole, H. & Watts, D.M. (2009). Communal e-learning styles in the online classroom. *Research in Education*, 82, 13-27.
- Dillon, J.T. (1998). Theory and practice of student questioning. In S. A. Karabenick (Ed.), *Strategic help seeking: implications for learning and teaching* (171-193). New Jersey: Lawrence Erlbaum Associates.
- Devlin, M. (2006). Challenging accepted wisdom about the place of conceptions of teaching in university teaching improvement. *International Journal of Teaching and Learning in Higher Education*, 18, 2, 112-119.
- Glenn, J.M. (2000). Teaching the Net Generation. *Business Education Forum*, 54, 3, 6-8, 10, 12-14.
- Graesser, A.C. & Person, N.K. (1994). Questioning asking during tutoring. *American Educational Research Journal*, 31, 104-137.
- Hayes, J. & Allinson, C. W. (1997). Learning Styles and Training and Development in Work Settings: Lessons from Educational Research. *Educational Psychology*, 17, 1-2, 185-193.
- Holmes, B. & Gardner, J. (2006). *E-Learning concepts and practice*. London: Sage Publications.
- Heimlich, J.E. & Norland, E. (2002). Teaching Style: Where Are We Now? *New Directions for Adult and Continuing Education*, 93, 17-25.
- Ironside, P.M. (2003). New pedagogies for teaching thinking: the lived experiences of students and teachers enacting narrative pedagogy. *Journal of Nursing Education*, 42, 11, 509-516.
- Jordan, B. (2004). Scaffolding learning and co-constructing understandings. In A. Anning, J.Cullen & M. Flear (Eds.) *Early childhood education society and culture*. California: Thousand Oaks.
- Pithers, B. (2001). An Aspect of Vocational Teachers' Cognitive Style: Field Dependence-Field Independence. *Australian and New Zealand Journal of Vocational Education Research*, 9, 2, 47-60.
- Pedrosa de Jesus, M.H., Almeida, P., & Watts, D.M. (2004). Questioning Styles and Students' Learning: Four Case Studies. *Educational Psychology*, 24,4, 531-548.
- Pedrosa de Jesus, M.H., Neri de Souza, F., Teixeira-Dias, J.J.C. & Watts, D.M. (2005). Organising the chemistry of question-based learning: a case study. *Journal of Research in Science and Technology Education*, 23,2, 179 – 193.

- Pedrosa de Jesus, M.H. & Silva Lopes, B. (2008) *Questioning strategies and teaching approaches': a study in university biology*. H. Broeck, C. Evans & T. Redmond (Eds.), Processings of the 13th annual conference of the European Learning Styles Information Network (385-408), Gent: Vlerik Leuven Management School.
- Pedrosa de Jesus, M.H. & Moreira, A.C. (2009). The role of students' questions in aligning teaching, learning and assessment: a case study from undergraduate sciences. *Assessment and Evaluation in Higher Education*, 34, 2, 193-208.
- Rogoff, B., Mistry, J., Goncu, A. & Moshier, C. (1993). Guided participation in cultural activity by toddlers and caregivers. *Monographs of the Society for Research in Child development*, 58 (Serial Number 236).
- Rop, C.J. (2002). The meaning of student enquiry questions: a teacher's beliefs and responses. *International Journal of Science Education*, 24,7, 717-736.
- Stitt-Gohdes, W.L. (2001). Business Education Students' Preferred Learning Styles and Their Teachers' Preferred Instructional Styles: Do They Match? *Delta Pi Epsilon Journal* 43, 3, 137-151.
- Stitt-Gohdes, W.L. (2003). Student Teachers and Their Students: Do Their Instructional and Learning Preferences Match? *Business Education Forum*, 57,4, 22-27.
- Stitt-Gohdes, W.L., Crews, T. B. & McCannon, M. (1999). Business Teachers' Learning and Instructional Styles. *Delta Pi Epsilon Journal*, 41,2, 71-88.
- Teixeira-Dias, J.J.C., Pedrosa de Jesus, H., Neri de Souza, F. & Watts, D.M. (2005). Teaching for quality learning in chemistry. *International Journal of Science Education*, 27, 9, 1123-1137.
- Trigwell, K., Prosser M. & Ginns, P. (2005). Phenomenographic pedagogy and a revised Approaches to Teaching Inventory, *Higher Education Research and Development*, 24, 349-360.
- Trigwell, K. & Prosser, M. (2009). Using phenomenography to understand the research-teaching nexus. *Education as Change*, 13, 325-338.
- Veiga, A. & Amaral, A. (2009) Survey on the implementation of the Bologna process in Portugal, *Higher Education*, 57, 57-69.
- Vygotski, L.S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.
- Walsh, J. & Sattes, B. (2005). *Quality questioning*. Thousand Oakes: Corwin Press
- Watts, D.M. (2003). The Orchestration of Learning and Teaching Methods in Science Education. *Canadian Journal of Science, Mathematics and Technology Education*, 3,4, 451-464.
- Watts, D.M. (2005). Orchestrating the confluence: a discussion of science, passion and poetry. In Alsop, S. (Ed.) *Beyond Cartesian Dualism: encountering affect in the teaching and learning of science* (148-159). Series: Science & Technology Education Library, Vol. 29, Kluwer Press: Dordrecht.
- Watts, D.M. & Pedrosa de Jesus, M.H. (2005). The cause and affect of asking questions: Reflective case studies from undergraduate sciences. *Canadian Journal of Science, Mathematics and Technology Education*, 4, 437-452.
- Watts, D.M. & Pedrosa de Jesus, M.H. (2006). *Enhancing University Teaching Through Effective Use of Questioning*. Special 19, SEDA(Staff and Educational Development Association): London.
- Watts, D.M., & Pedrosa de Jesus, H. (2007). Asking questions in classroom science. In K.S. Taber (Ed.), *Science education for gifted learners* (112-127). Oxon: Routledge
- Watts, D.M., Pedrosa de Jesus, M.H., Silva Lopes, B., Moreira, A. & Almeida, P. (2009, November). *Questions in context, the context of questions*. Paper presented at the 2nd International Seminar on Research on Questioning, University of Aveiro, Portugal.

Table 1. Preferential Teaching Approaches (Trigwell, Prosser & Ginns, 2005, Trigwell & Prosser, 2009)

| | <i>Teaching/Learning Concept</i> | <i>Teaching Intention</i> |
|-------------|---|---|
| ITTF | Teaching is the transmitting of information (“teaching-by-telling”) Learning is the accumulation of information with the aim of accomplishing external demands | Students acquire the contents of the discipline and are able to connect them and fulfil test requirements |
| CCSF | Teaching is to support students in developing and changing concepts Learning is developing and changing concepts | To help students to construct their knowledge by confronting and changing their perceptions of the concepts |

Table 2. Zone 1: a context of high formality

| Components of context | Description |
|------------------------------|--|
| Setting | University teaching laboratories, science lecture theatres, conferences, seminar room; week days during a university semester in Portugal (and many places elsewhere) |
| Social | Formal, authoritative, exam-orientated contexts, ‘teaching to the tests’, tangible power-relationships; note-taking, assignments, laboratory classes, formalised formulaic teaching and learning tasks |
| Individual/ Personal | Socially compliant students who are inhibited in their question-asking, with few opportunities to ask informative, specialist or speculative questions in the quiescent atmosphere of a formal lecture system; teachers orientated towards ‘Information transmission, teacher-focused’ (ITTF) approaches to teaching (Trigwell, Prosser & Ginns, 2005, Trigwell & Prosser, 2009) |

Table 3. Zone 2: A context of low-conformity

| Components of context | Description |
|------------------------------|--|
| Setting | Tutorials, small-group work, 'learning sets', enquiry-based learning, mini-projects, classroom presentations, field-work, study-centres, on-line discussion forums; own-time, off-site research, on-line opportunities, self-directed, self-paced |
| Social | Teachers create conducive social contexts in which original and creative activities are rewarded without fear of failure; fosters original and unexpected thinking, with more-or-less equity between members, enables questions; teachers and taught provide and role-model 'creative questioning'; tasks include mini-projects, supplementary tutorials, on-line discussions, own-time learning, field work |
| Individual/ Personal | Students reveal a high disposition to raise questions, encouraged and uninhibited by peers, teachers or circumstances; teachers orientated towards 'conceptual change student-focused' (CCSF) approaches to teaching (Trigwell, Prosser & Ginns, 2005, Trigwell & Prosser, 2009) |