

## **Promoting questioning skills by biology undergraduates: The role of assessment and feedback in an online discussion forum**

*Helena Pedrosa-de-Jesus and Aurora Coelho Moreira*

*Research Centre for Didactics and Technology in Teacher Education, Department of Education, University of Aveiro, Portugal*

### **ABSTRACT**

There is strong evidence from the literature that the development of questioning by students can have very positive effects on learning. This study has its focus on an online discussion forum (ODF), “Questions in Biology”, designed for the development of questioning skills and deep learning about Evolution. This strategy was also used as an alternative mode of students’ assessment. The ODF was used with 70 undergraduates from Biology/Geology courses at the University of Aveiro, Portugal, during the second semester of 2008/2009. Our aim was to explore student questioning and learning development as well as the role played by assessment and teacher feedback in these processes.

Data collected included all the student and teacher transcripts from the discussion forum and interviews with ten selected students and the teacher. All the transcripts were subjected to content analysis. Students’ posts were categorised against the Acquisition-Specialization-Integration questioning categories, developed by Pedrosa-de-Jesus and colleagues (2004, 2006) and the ‘cognitive presence’ in one of the four phases of the ‘practical inquiry model’: 1) triggering event; 2) exploration; 3) integration, and 4) resolution. The teacher’s posts were analysed according to the ‘teaching presence’: 1) design and organization, 2) facilitation and 3) direct instruction.

Data analysis showed important relationships between student questioning and cognitive presence that indicates the development of student questioning in association with higher-order learning. Teaching presence was shown to be effective, and the feedback provided by the teacher essential for attaining those fundamental goals. Very positive opinions by the students and the teacher confirmed the importance of formative assessment and the role of assessment aligned to teaching, learning and the desired outcomes.

We believe that “Questions in Biology” represents a good example of formative assessment and a positive contribution for the adoption of teaching, learning and assessment practices in Higher Education envisaging higher-level learning.

### **THEORETICAL CONTEXT**

#### **Student questioning**

Questioning practices vary deeply from person to person, with significant impact on personal achievements. There is strong evidence from research literature in this field that the development of questioning by students can have very positive effects on learning (Dillon, 1986; Dori and Herscovitz, 1999; King, 1994; Pedrosa-de-Jesus, 1991). By

asking questions, students become more actively engaged in learning, stimulating cognitive processes and revealing their thinking frameworks.

Some previous studies by Pedrosa-de-Jesus and colleagues (Pedrosa-de-Jesus, Almeida and Watts, 2004; Pedrosa-de-Jesus, Almeida, Teixeira-Dias and Watts, 2006) investigated and confirmed relationships between students' questioning, Kolb's experiential learning and approaches to learning, concluding that students' questions are good indicators of students' learning development (Pedrosa-de-Jesus et al., 2004, 2006). The authors strongly emphasise the importance of encouraging students to ask questions in order to promote deep learning approaches.

Questions are emerging as a very powerful instrument for assessing students' knowledge, acting as diagnoses of their understanding (Dillon, 1986; Pedrosa-de-Jesus, Teixeira-Dias and Watts, 2003). Questions can also provide teachers with important evidence on learning gains and misconceptions, helping to tune teaching strategies (Dillon, 1986; Pedrosa-de-Jesus, 1991). This suggests that students' questions should also be used in assessment for learning, acting as alternative means for assessing knowledge and learning development (Dori and Herscovitz, 1999). The use of question-posing skills as alternative assessment tools has already been described in the literature with success, suggesting the improvement of learning through fostering question-posing skills (Dori and Herscovitz, 1999; Pedrosa-de-Jesus and Moreira, 2009; Zoller, 2001).

### **Online discussion forums**

Educational practices reflect a growing adoption of computer tools to foster online collaborative learning. Online discussion forums (ODF) have been used extensively and are one of the most commonly used tools (Saadé and Huang, 2009). These asynchronous text-based discussions present several advantages for students: more opportunities to interact with each other, more time to reflect, to think, and to search for further information before making a contribution to the discussion (De Wever, Schellens, Valcke and Van Keer, 2006). The discussion generated between peers is seen as promoting learning, and the ensuing discourse is regarded both as reflecting and shaping the cognitive processes, which are in these contexts of a social nature. The construction of knowledge is indeed a social and dialogical process in which students should be actively involved (Saadé and Huang, 2009).

However ODFs present some problems: they are difficult to structure and to moderate, and require a "large amount of effort, resources and time" to do so. Also, it is very complex to define and achieve a desired outcome from online discussion forums (Saadé and Huang, 2009: 88). Another disadvantage could be, for example, the removal of time constraints, which may involve both instructors and students with never-ending opportunities to learn and work. Additionally, "the lack of visual communication cues is another significant disadvantage", forcing users "to make certain assumptions about their audience" (Hara, Bonk and Angeli, 2000:116)

Still, some authors believe that higher-order learning can be developed in computer-mediated learning environments (Garrison, Anderson and Archer, 2001). For instance, Garrison and colleagues have developed a framework as a “means to assess the nature and quality of critical, reflective discourse that occurs within a text-based educational environment” (2001:7). This framework for a community of inquiry focused on “the genesis and manifestation of the cognitive presence concept” as being most central to their model and to the success of educational experiences (Garrison et al., 2000). Cognitive presence is grounded in the critical-thinking literature and has been defined as “the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry” and it “has the potential to assess the quality of critical inquiry in terms of providing a means to assess the systematic progression of thinking over time” (Garrison et al., 2001:11). Cognitive presence is a “vital element in critical thinking” (Garrison et al., 2000:89), which in turn is considered an overall goal of higher education.

These authors believe that their framework “provides directions for future research focusing on the facilitation of higher-order learning” (Garrison et al., 2001:22). In spite of the importance of these asynchronous discussion forums, the methods used for assessing their content and outcomes has predominantly been limited to frequency counts and other quantitative measures. Qualitative analysis of online discussion forums is considered to be fundamental to assess its contents and outcomes (Marra, Moore and Klimczak, 2004:23).

### **Assessment for learning and feedback**

Studies in the last decade have clearly revealed the central role of assessment practices in the learning process (Brown and Knight, 1994; Dochy and McDowell, 1997). Students’ engagement in learning is commonly ruled by the demands of assessment (Gibbs and Simpson, 2004; Boud and Falchikov, 2006), which strongly influences their behaviour and the adopted study methods. When used as a tool for learning (Black and William, 1998), assessment helps students to gain insight into their progress (Dochy and McDowell, 1997), supporting appropriate engagement (Heywood, 2000; Wiliam, Harrison, and Black, 2004), as well as promoting higher cognitive competencies.

Recent work by Black and Wiliam (2009:8) towards the development of a theory for formative assessment provides a framework that conceptualizes formative assessment in five key strategies for practice. These strategies are illustrated in Figure 1 and take effect in ‘moments of contingency’, which represent opportunities for students’ understanding to move forward. These moments can be synchronous or asynchronous, where “the teacher and the learner exercise the capacity for things to be ‘otherwise’ in terms of the learner’s understanding or attainment” (Daly, Pachler, Mor and Mellar, 2010:622).

In formative assessment the feedback channels can be diverse: teacher–learner(s), learner(s)–teacher, learner–learner(s). High-quality interactions between the teacher and the learners, such as questioning, listening, responding and reflecting, should be promoted in order to be integral to the learning processes (Daly et al., 2010:620)

	Where the learner is going	Where the learner is right now	How to get there
Teacher	<b>1</b> Clarifying learning intentions and criteria for success	<b>2</b> Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding	<b>3</b> Providing feedback that moves learners forward
Peer	Understanding and sharing learning intentions and criteria for success	<b>4</b> Activating students as instructional resources for one another	
Learner	Understanding learning intentions and criteria for success	<b>5</b> Activating students as the owners of their own learning	

**Figure 1 – Aspects of formative assessment (in Black and Wiliam, 2009:8)**

The framework proposed by Black and Wiliam also helps to clarify the complexity of formative assessment within e-learning contexts. Findings by Daly et al. (2010: 634) suggest that “formative e-assessment is an extremely complex phenomenon, and is best understood as a set of processes involving both technological and social resources”. E-learning contexts create learning conditions in which it is difficult to establish a boundary between formative and summative assessments. There is a tendency to conflate formative and summative assessments with a view of ‘adaptivity’, here considered as a core component of e-assessment processes that involve “those practices which enable the learner to adapt and close the gap between current understanding or attainment and a further stage or level, that is it has a future trajectory” (Daly et al., 2010: 621).

Besides the role formative assessment should play as a core component of any educational experience, other fundamental aspect to consider when designing teaching, learning and assessment is the constructive alignment, according to Biggs’ conception (1999). All the assessment tasks should be properly designed to directly assess each of the intended learning outcomes defined in the curriculum. In that sense assessment should be properly aligned with the teaching and learning processes (Biggs, 1996, 1999; Hofstein, Navon, Kipnis and Mamlok-Naaman, 2005; Segers and Dochy, 2006).

That was a fundamental aspect when designing the “Questions in Biology”, an online discussion forum for developing and assessing student questioning and higher-level learning. The design of an innovative and alternative learning environment that would promote deep approaches to learning and the development of a coherent assessment practice with learning and instruction were initial challenges of the discipline of Evolution during 2008/2009. Designing and conducting an asynchronous online discussion plays a significant impact on the nature of interactions and influences the way students approach their learning. Evidence of higher-order learning is usually related to the context of the learning environment and to an effective teaching presence that encourages participation and triggers discussion (Garrison and Cleveland-Innes, 2005). If deep approaches to learning are to be achieved, then there must be a specific design goal,

providing clear participation requirements and content expectations. Also, assessment should be congruent with the intended goals (Garrison and Cleveland-Innes, 2005).

The belief that student questioning and deep approaches to learning could be promoted through the participation in the “Questions in Biology” forum, lead to the following research questions:

- a) What are the main characteristics of students’ questioning registered in “Questions in Biology” ODF? ;
- b) Can we find evidence of students’ deep approaches to learning and learning development from their on-going participation in this discussion forum? ; and
- c) What is the influence of assessment feedback in students’ participation in that ODF?

This lead to the following purposes: i) to analyse students’ questioning adopted during the discussion; ii) to find evidence of student’s learning development, and iii) to find evidence of the role of assessment and the teacher’s feedback during discussion.

## **METHODOLOGY**

This work is part of a broader naturalistic research, conducted at the University of Aveiro since 2007/2008 with four collaborating professors from the Biology Department. The main aim has been the promotion of questioning by biology undergraduates, through the design of specific teaching, learning and assessment strategies. This paper focuses on “Questions in Biology”, an online discussion forum designed in collaboration with the professor responsible for the curricular unit of Evolution, and addressed to 70 undergraduates from Biology and Biology/Geology courses, during the second semester of 2008/2009.

The “Questions in Biology” forum was open and available for students’ participation during all the semester and its contents were related to the topics being covered during lectures. Challenges were introduced by the teacher at particular moments, who also monitored student participation and gave feedback whenever appropriate. The discussion was not intended to be teacher-centred. Instead, interaction was to be facilitated in a sustained manner, by moderating and shaping the direction of the discourse. There was a first phase of adaptation, over a three-week period, where students were given orientations and guidelines on how to participate in a meaningful manner, not being part of summative assessment.

After that adjustment period, students’ participation was assessed by the teacher, according to the number and quality of the messages posted, during the following six weeks. Students were given specific dates for participation in each of the two periods. The purpose was to encourage students to participate evenly throughout the semester and try to prevent the completion of their posts at the last minute. After the initial challenge

posted by the teacher, the students were free to create new topics for discussion and to choose the topics they would like to engage. The discussion activity of two posts per theme was mandatory to obtain the marks.

The assessment criteria were shared and discussed with students at the beginning of the semester, including the frequency (number of posts by student) as well as the cognitive level of the messages, according to the Acquisition, Specialisation and Integration categories for questioning (Table 1), also adopted for the purpose of this research, which will be detailed further on. Participation in the discussion forum over that 6-week period was worth 7.5% of the students' final grades.

All the written contributions to the online discussion forum were collected for research purposes, and subjected to content analysis. The complete messages (or posts) were chosen as the basic unit of analysis, that is, those forming a complete 'unit of meaning'. We assume that analysing student questioning should not be limited to the sentence or question *per se*, since the entire message is important to contextualize and understand the thinking processes underlying questioning. Also, "a complete message provides coders with sufficient information to infer underlying cognitive processes" (Garrison et al., 2001:16-17). All the messages from the online discussion forum were analysed against the ASI categories for questioning (Table1), according to Pedrosa-de-Jesus et al. (2004, 2006) and shown in Table 1:

Acquisition questions (A)	Specialization questions (S)	Integration questions (I)
Deal with relatively simple ideas, objects, processes, or concepts, which do not require evaluation, judgement, or drawing conclusions; an attempt to elucidate issues, to confirm explanations or to clarify conceptual issues; ‘stick-to-the-facts’ questions, whose answers will mainly rely upon memory processes. The learner is looking fundamentally for basic information.	Tend to go beyond the mere search for information; these questions transcend the specific or detailed level of comprehension, in order to generalize or relate these specifics into meaningful patterns. The student establishes relations and tries to understand and interpret the surrounding world. Students seek to both expand knowledge and test constructs that they have formed.	Reorganization of concepts into novel patterns; hypothesize new or different applications of principles learned. Integration questions are attempts to reconcile different understandings, resolve conflicts, test circumstances, force issues, and track in and around complex ideas and their consequences. The integration phase may also include characteristics from the specialization phase.

**Table 1 – Categories for questioning analysis (ASI system) (Pedrosa de Jesus et al., 2004, 2006)**

According to Pedrosa-de-Jesus et al. (2006), students tend to ask questions that are congruent with their stage of learning development, being directly related to the acquisition, specialisation and integration phases defined and characterised by Kolb (1999). Students in the acquisition phase ask mainly acquisition questions, which are also associated with surface approaches to learning – surface questions. Students in the specialisation stage, ask mainly specialisation questions, lying in between deep and surface questions and sharing characteristics of these two kinds of utterances. Accordingly, students in the integration phase will show the ability to ask higher-level questions or integration questions, being able as well to ask the other types of questions, according to the learning context, the learning demands and their needs.

It is important to note that the ‘enquiry disposition’ of the student might be embedded in the message without them having explicitly formulated a question. So, all the messages were coded against the ASI categories even if students had not formulated explicit questions (sentences followed by a question mark).

After we had coded the transcripts against the ASI categories, we decided that it could be of great relevance for our purposes to also analyse the students’ messages according to the Practical Inquiry Model proposed by Garrison et al. (2000, 2001). This would give another dimension to the analysis by means of assessing and finding evidence of ‘cognitive presence’ within the transcripts. The CoI (Community of Inquiry) framework

has already been validated by a number of studies (Arbaugh, Cleveland-Innes, Diaz, Garrison, Ice, Richardson and Swan, 2008; Garrison and Arbaugh, 2007) and “has been shown to be reasonably robust” (Garrison, Anderson and Archer, 2010: 8). The ‘cognitive presence’ dimension operationalizes in four categories as described in Table 2. The goal in deep learning is to move discussion from exploration, to integration and then to resolution.

Initiation phase (triggering event)	Exploration phase	Integration phase	Resolution phase
An issue, dilemma, or problem that emerges from experience is identified or recognized. The teacher often explicitly communicates learning challenges or tasks that become triggering events <u>Examples of indicators:</u> recognizing the problem; sense of puzzlement.	Participants shift between the private, reflective world of the individual and the social exploration of ideas. Reflects an inquisitive and divergent process in the search for ideas to help make sense of a problem or issue. <u>Examples of indicators:</u> information exchange, brainstorming, questioning.	Constructing meaning from the ideas generated in the exploratory phase. Represents the construction of a possible solution. Tentative conversation or connecting of relevant ideas capable of providing insight into the dilemma (convergent phase). <u>Examples of indicators:</u> connecting ideas, synthesis; creating solutions.	Process of critically assessing the concepts, representing a commitment to a solution (resolution of the problem created by the triggering event). Consensus building within the community of inquiry. It requires clear expectations and opportunities to apply newly created knowledge. <u>Examples of indicators:</u> vicariously apply new ideas, critically assess solutions.

**Table 2 – Categories for 'Cognitive Presence'- (adapted from Garrison et al., 2001)**

Also, teacher participation in the forum was analysed, considering the “teaching presence”, a concept defined by Anderson, Rourke, Garrison and Archer (2001:5):

“the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes.”

Teaching presence that “encourages participation, but is not teacher centred” (Garrison and Cleveland-Innes, 2005:145) has been shown to be “crucial in the satisfaction and success of a formal educational community of inquiry” (Arbaugh et al., 2008:134) and is significant in determining “student satisfaction, perceived learning and sense of community” (Garrison and Arbaugh, 2007:163). Teaching presence is multi-dimensional, consisting of three components (Table 3) that provide valuable guidelines for creating and sustaining cognitive presence in an online educational environment:

<b>Design and organization</b>	<b>Facilitation</b>	<b>Direct instruction</b>
Involves “designing and administering appropriate activities that take place during the course”; negotiating time lines; “providing guidelines and modelling appropriate etiquette and effective use of the medium” as well as “students’ awareness of the explicit and implicit learning goals” (Anderson et al., 2001:6). The design of the structure, process, interaction and evaluation aspects of the online course are particularly important activities and one of the most consistent predictors of successful online courses (Swan, Richardson, Ice, Garrison, Cleveland-Innes and Arbaugh, 2008). This role is most likely to be performed exclusively by the teacher, and occur essentially in the pre-course activities.	“This role includes sharing meaning, identifying areas of agreement and disagreement, and seeking to reach consensus and understanding” which “requires the instructor to review and comment upon student comments, raise questions and make observations to move discussions in a desired direction, keeping discussion moving efficiently, draw out inactive students, and limit the activity of dominating posters when they become detrimental to the learning of the group” (Swan et al., 2008:3).	Teacher’s “provision of intellectual and scholarly leadership in part through the sharing of their subject matter knowledge with the students” (Anderson et al., 2001). This role includes “diagnosing comments for accurate understanding, injecting sources of information, and directing discussions in useful directions, scaffolding learner knowledge to raise it to a new level”. To play this role instructors must have both “content and pedagogical expertise to make links among contributed ideas, diagnose misperceptions, and inject knowledge from textbooks, articles, and web-based materials. Instructor responsibilities are to facilitate reflection and discourse by presenting content, using various means of assessment and feedback. Explanatory feedback is crucial.

**Table 3 – Components of ‘Teaching Presence’**

Beside the content analysis of all the forum transcripts concerning the three dimensions considered – student questioning, cognitive presence and teaching presence – semi-structured interviews also took place at the end of the semester (June 2009). Ten students were selected according to their diverse mode of participation in the forum to explore their opinions about the “Questions in Biology” forum as well as the influence of assessment and feedback on their participation. The teacher was also interviewed in order

to better understand his opinion about the effectiveness of this strategy concerning the initial goals and the achievement of students' intended outcomes. The interviews were transcribed verbatim and subjected to content analysis. It is very important to complement data from the interviews with those from the discussion forum.

The data collection, both from the online discussion forum and interviews, was carried out with the informed consent of the students and teacher. We have employed pseudonyms in order to guarantee student and teacher anonymity in line with university ethics procedures.

The transcripts selected for illustrating important aspects of discussions were translated into English by the researchers, the authors of this paper, since the language of instruction was Portuguese.

## FINDINGS AND DISCUSSION

### Student questioning and cognitive presence

Two hundred and five students' posts were collected for summative assessment, corresponding to their participation during the six-week period. It is important to clarify that during this period the teacher introduced two main challenges on specific dates previously agreed with students. The first challenge opened the first 3-week period and the second one took place during the final 3-weeks. Each student should post at least two messages during each period in order to assure a continuous participation and its inclusion in final assessment.

From the total number of students attending this curricular unit, 14 did not participate at all in the online forum, 39 students participated during the 6-week period and 17 only have participated on the first challenge corresponding to the first 3 weeks (Table 4).

Type of participation	Number of students	% Students
No participation	14	20%
Participation only in the 1 <sup>st</sup> challenge	17	24%
Participation only in the 2 <sup>nd</sup> challenge	0	0
Participation in both challenges	39	56%
Total	70	100%

**Table 4 – Students' participation in the forum**

The total number of student posts during the first challenge was 126, representing a mean number of 2.25 messages per student. During the final challenge the number of messages

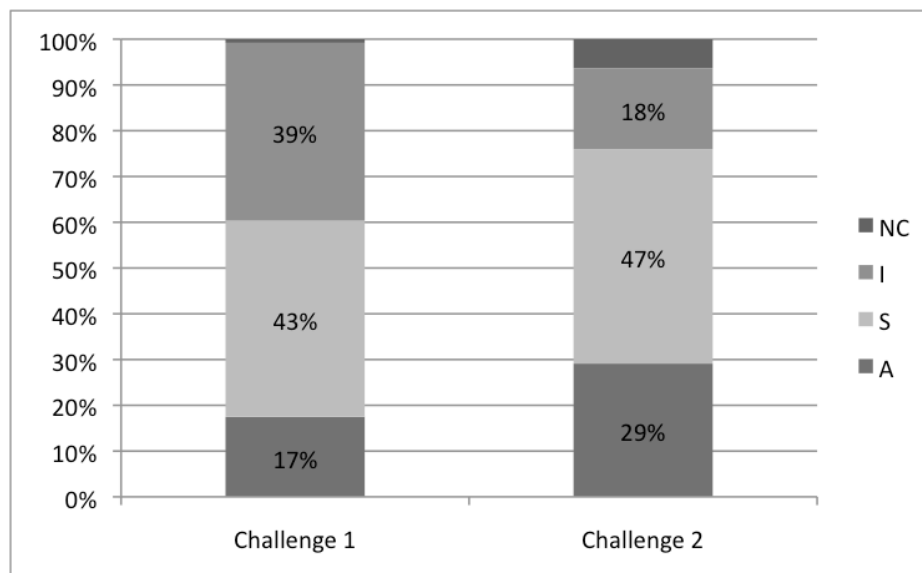
decreased (79 messages) considered as a direct consequence of the reduced number of students involved, when compared to the first challenge. However, the mean number of messages per student was not so different, corresponding to two messages per student, having satisfied the minimum requirement.

Student feedback from the interviews revealed that another reason associated with this decrease in participation during the second challenge could be the nature of the theme itself and some difficulties in dealing with the topics addressed:

Jorge: “For example, on the last theme, I was not able to comment until the day before because I thought it was too complex, and there were too many things to read (...) I didn’t know what to write, it was a theme difficult to comment on.”

We could also consider it as one of the reasons to explain the decrease in the number of integration episodes on the second challenge (Figure 2). Also, many messages were posted close to the deadline during this challenge, which could have compromised its quality, as stated by Manuel:

Manuel: “When I realised that the deadline was so close I said to myself “I need to do something!”... but I saw so many things written in the forum that I realized I wouldn’t have time to read it all, so I have decided to chose 2 or 3 topics and answer them... I wrote just a brief message based on those topics.”



**Figure 2 – percentage of student posts in each challenge according to the ASI coding system (NC stands for non-classified posts)**

Besides that, the global results from the ASI coding could be considered as very positive (Figure 2). According to the literature on questioning, the frequency of questioning episodes at the integration level tends to be lower, even when written communication is

privileged. Accordingly, the acquisition level of questioning tends to be generally more expressive (Pedrosa-de Jesus et al., 2006).

However, we cannot draw a straight conclusion regarding student progression in learning. After analysing each student message according to the ASI questioning scheme we have found that no particular patterns of questioning could be associated with individual student progression in learning. It would be expected that we could find an improvement in question-posing by students during the participation in the forum, from the acquisition phase to the integration phase, which would, in turn, reflect a progression in the learning continuum. Instead, we found that nearly all students (around 80%) were able to employ any of the three approaches to questioning, based on the different requirements of the discussion. Students moved from one approach to another depending on the context of the learning environment. This was clearer with students who posted a higher number of messages. Some contextual factors that were indicated in the development of deep learning and that may have played a influence here could be “the workload and time constraints, the opportunity for metacognition, the shift of learning management to the students themselves, and instructor explanation, enthusiasm and empathy” (Garrison and Cleveland-Innes, 2005:138). ‘Context’, “in technologically enhanced learning situations, becomes a malleable concept”, (...) “it is constantly evolving and being re-made by learners: they make changes in the ways they interact with others and with technologies, and thus change the learning conditions which exist and which shape what can be done next”. (Daly et al., 2010:633). The context of the learning environment would influence the way students approach their learning. In an “engaging, instructive and influential learning environment, an increase in deep learning is the change most likely to occur” (Garrison and Cleveland-Innes, 2005:139).

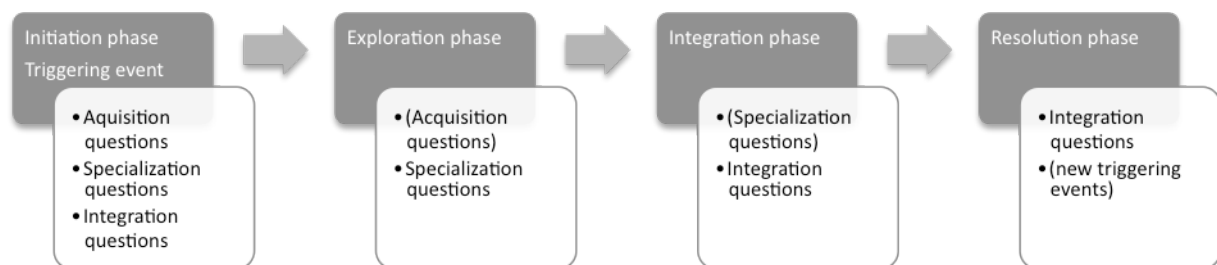
Also, some other factors may contribute to the complexity associated with the analysis of students’ learning development during an ODF: (i) knowledge construction and progression in learning in these environments are not an individual endeavour, but a collaborative and social one; (ii) different and parallel themes or challenges addressed at the same time; (iii) previous posts from other participants might, or might not, have an effect on a particular student intervention; (iv) the presence and type of interaction between the students and the teacher is variable; (v) the teacher presence is an important influence for the development of the discussion.

For those reasons, we also decided to analyse the student transcripts according to the four phases for cognitive presence, trying to find relationships with the student approaches to questioning previously identified. This would be a contribution to characterise the type of preferential questioning occurring in each phase of practical inquiry. Assessing and finding evidence for cognitive presence has some methodological challenges. It is an inductive and subjective process by the observer/coder, since the transcripts analysed are part of the process that is made visible and public (Garrison et al., 2001).

Another difficulty could be the use of message posts as a coding unit, which can have very different lengths. A single message can address a variety of topics and may contain “some contradictory categorization cues or evidence of multiple phases of cognitive

presence”. In these cases it is “important to regard that higher levels of critical thinking, such as integration and resolution, borrow characteristics and process from previous phases”, so the coding-up (i.e. to the latter phase) is recommended when evidence of multiple phases is present (Garrison et al., 2001:17). In fact, we have found some difficulties in coding integration and resolution phases. According to Garrison and colleagues (2001:11), “progression to the fourth phase requires clear expectations and opportunities to apply newly created knowledge” and can also represent a “moving on to a new problem with the assumption that students have acquired useful knowledge”; this can lead to “further problems and new triggering events, thus causing the process to start over.”

Besides the difficulties concerning the content analysis process, we can however establish some relationships between the levels of student questioning and the phases of the inquiry process, manifested by cognitive presence (Figure 3). Indeed, there is evidence of a tendency for the exploration phase being mainly associated with questions at the specialisation level as well as some questions at the acquisition level. This is a brainstorming phase where students feel free to share their insights, trying to expand knowledge and test their ideas. Accordingly, high-level questioning is mainly a characteristic of the latter phases. In the integration phase we can find mainly integration questions, but also episodes where the specialisation approach prevails. The resolution phase was mainly characterised by the presence of the integration questioning approach. However, since this phase can be classified by the upcoming of new triggering events, causing a new initiation phase, it was sometimes difficult to categorise it, since these episodes can reveal different types of questioning. As a result of this, it is possible to identify/classify triggering events at all of the questioning levels. Apart from being an initiation phase it does not necessarily mean that it has to be characterised by low-level questioning. For example, triggering events that have resulted from a resolution phase can be characterized by integration approaches to questioning.



**Figure 3 – Relationships between questioning approaches and phases of cognitive presence**

Generally speaking, the creation of this online forum as an opportunity for written communication seems to have contributed to enhance the development of student questioning and higher-level learning about Evolution. Text-based communication provides time for reflection, for organising and structuring ideas, for encouraging discipline and rigour in thinking and communication, being very closely connected to the development of critical thinking (Garrison et al., 2000).

The students interviewed reinforced these qualities of the forum in promoting knowledge construction as well as the development of important competencies in higher education:

Ana Sofia: “I think that there is a need for a person to evolve, to devote great effort in overcoming higher levels of difficulty (...) This (*forum*) stimulated us to a new activity, allowing me to use other techniques of research, a research addressed to a discussion, a theme that was going to be discussed with other people, so I had to be well prepared in case someone would ask me a question that I would have to answer. So, I think it was very positive in that respect.”

Emanuel: “I think we have basically developed critical thinking. In fact, I realise that along the semester.”

Bruno: “Biology is very linked to practice and nowadays for a person to be successful has to have not only his theory or study, but also know how to communicate it and make it public to the scientific community, and I think in that respect this strategy helped.”

Alexandre: “The access to the Internet is very positive for shy people or, for some reason, have fear to talk. I recognize that some colleagues who never talk during classes were the most participative students in “Questions in Biology”. This shows how is important to give opportunities for these people to express their ideas. (...) (*the writing process*) was also very important for effectively developing other capacities such as citing others’ work, to search for information and write our text and our ideas with scientific support. It really helped us in doing that, and we get used to doing it.”

The teacher also shared these opinions by stressing the importance of this discussion forum in attaining fundamental goals and providing the development of learning and some competencies such as questioning or critical thinking:

“In this case, writing online comments requires groundwork from the students; they need to investigate the subject, which sometimes is not even approached during lectures. If they want to make a critical analysis probably they will need to get specific literature to support their ideas, and this involves a lot of work” (...) “When raising a question, there are dimensions that probably we didn’t even think they will need to work in order to develop that question. When formulating a question some background is needed for supporting it; if the background knowledge is limited it will also limit the formulation of a question... And of course, there are different levels of questions, a direct question is an immediate question, a very easy one, but a more elaborated question requires groundwork from the student that implies more time devoted, more time to think about these subjects.”

### **Teaching presence and feedback**

Fostering a deep approach to learning involves the design of assessment congruent with the development of the intended goals, in this case questioning and deep learning. Regarding “Questions in Biology” as an alternative mode of assessment, the interviewed

students have expressed their opinions, generally agreeing with its' inclusion in the assessment process:

Paulo: "I think that to change teaching, the modes of assessment should be changed first. (...) The "Questions in Biology" is a very important strategy but it has to be assessed. Otherwise students, and I speak by myself, won't participate as they are not obliged to do so."

Inês: "It is important for us to start developing some competencies, since we are going to be biologists. So I believe that it is important to have other strategies of assessment besides the exams so we can end up developing the competencies that are going to be assessed by those methods. (...) this method of assessment accounts for our capacity of questioning and argumentation... and formulating questions when we have a topic in front of us is in fact important."

Also, they all agree about the impact of assessment on student engagement:

Teresa: "Of course it influences, it is an assessment... In fact, it was evident during the formative period where the number of participations was less than half when comparing with other (*challenges*) for summative purposes. If it counts for assessment people devote more attention."

João: "I think that the students' head is formatted for what is going to be assessed, independently from other underlying goals. Maybe the teachers intend to stimulate us, and we are stimulated without knowing it, but our goal is only to think about assessment... we are guided by the "number" (*final grade*), and if that number is not going to be affected, we will not consider that strategy... If "Questions in Biology" wouldn't have been considered for assessment, less people would participate, although it would be still an important strategy."

As described briefly before, the online forum was introduced with guidelines and specific orientations on how to participate meaningfully as well with the clarification and discussion of the assessment criteria with students. There was also a first period for adaptation where students were particularly asked to read all the previous comments and to structure their intervention according to the guidelines, supporting them with relevant literature whenever possible. This first period of formative assessment was considered as an essential component of the online forum. We believed that its development would raise the standards of students' interventions. The interviewed students confirmed our expectations being very positive about the provided guidelines:

Inês: "I think it was very important for us to have that structure. It is very important to have a model, otherwise, I would have participated anyhow but without considering it. In that case it wouldn't have been created a chain of participations that allowed for answers and even more questions, besides the initial topic."

Alexandre: "It is always important to know the assessment criteria. In every discipline we should know where and how we are going to be assessed (...). Concerning the "Questions

in Biology” it was effectively positive to have clarification, that way I knew how a comment with some characteristics would be assessed ...”

Students greatly valued the teacher’s feedback, being very concerned to follow his comments and to continue the discussion with him.

According to Black and Wiliam (2009:17), preparing effective feedback involves two steps, “the diagnostic in interpreting the student contribution in terms of what it reveals about the student’s thinking and motivation, and the prognostic in choosing the optimum response: both involve complex decisions.”

The use of student answers “to catalyse their further involvement in a learning discourse between peers” is far more complex than “dealing with a single student’s response in an individual tutorial” or a whole-class dialogue, although the teacher has more “time to consider how best to respond” (Black and Wiliam, 2009:25). The subsequent interactions will be a one-to-one interchange with students engaging in monologues without connecting to other contributions. This is in fact one of the challenges that teachers face when managing discussion (Garrison and Cleveland-Innes, 2005) which was evident from the initial interactions of “Questions in Biology” where students have replied directly to the teacher, constructing meaning in an individual and isolated manner. The teacher realised this behaviour very soon, in spite of the emphasis put on the importance of students’ interactions:

“I realised that very soon. After I have written a post, the discussion between the students tended to drop. Messages were posted with the perspective of delivering a message to me. But that was not the point. It was **their** discussion.”

The teacher had a fundamental role in dealing with this problem, structuring his participations by integrating his own and other students’ ideas, giving structure and guidance for ongoing participation. It is known from the literature that “teaching presence contributes to the adoption of a deep approach to learning and that interaction by itself does not promote a deep approach to learning” (Garrison and Cleveland-Innes, 2005, p.140). The progression along the inquiry process, ensuing continuing cognitive development, especially in the later phases, requires active teaching presence to diagnose misconceptions, to provide probing questions, comments, and additional information.

The teacher participation in the forum resulted in a total number of 16 interventions along the 2 periods, 8 posts for each period. This finding shows that students dominated the discussion, not the teacher, making this forum more student-centered, which was one of the initial challenges. The teacher tried to purposefully create a learning environment wherein students were in charge of their own learning and responsive to each other.

All the teacher’s messages were analysed (content analysis) against the categorization proposed by Anderson et al. (2001) for teaching presence, as described before: a) design and organization, b) facilitation, and c) direct instruction. It is important to stress that the teacher was not familiar with the concept and categories for teaching presence. His

participation in the forum was personal and intuitive, not following any guidelines on how to give feedback to students.

We have followed the guidelines suggested by the authors concerning the coding process allowing for the “possibility that a single message might exhibit characteristics of more than one category” (Anderson et al., 2001:11). Only one of the teacher’s posts showed indicators for the “design and organization” category, which is not a surprising result since this kind of teacher role took place mainly during the lectures before the forum had been initiated. The largest number of teacher messages (N=8) included two categories of teaching presence, both “facilitation” and “direct instruction”, as is illustrated in Table 5. A recent study on the validation of the teaching presence category confirms a “high degree of correlation” between the three dimensions for teaching presence which “implies that the online learning environment is a demanding one where the instructor has to fulfil all three dimensions of teaching presence well”; in other words, addressing one or two of the components “will not be enough since all three components are distinct yet highly correlated with each other” (Arbaugh and Hwang, 2006:17). According to this, our findings suggest that teaching presence was effective, since all the dimensions were identified in the teacher’s participation. Although, the “design and organization” category was not so expressive in the posts, this dimension was predominant in face-to-face lectures before starting the forum and in some of the lectures during the forum.

	“Facilitation”	“Direct instruction”	“Facilitation” + “Direct instruction”	“Design and organization”+“Facilitation” + “Direct instruction”
1st period	1	2	5	-
2 <sup>nd</sup> period	1	3	3	1

**Table 5 – Classification of teacher posts**

Besides this, it is important to stress the teacher’s opinion and experience when delivering feedback to students and some of the limitations associated. According to him, it was not always possible to give appropriate feedback, particularly when the number of posts was too large in a short period, which happened mostly near the deadline of each period of participation. According to him, the difficulties in addressing effective feedback are one of the major problems of online discussion forums:

“I believe that the big problem about the “Questions in Biology” is the feedback that the teacher is able to give during the semester. There are some moments where the number of students’ participations increases a lot, and being actively engaged and giving feedback really difficult to accomplish.”

The teacher has also considered the assessment of student posts, according to their level of quality in the ASI system, as a very demanding task:

“It was very complicated, but fortunately we have decided upon those criteria, and using those guidelines made it easier to me... But I think it’s extremely complicated, actually I had to go back when I was classifying ... because classifying all those questions in those students contexts and trying to be fair and objective, it’s complicated... for several times I needed to go back and check.”

Another difficulty of this type of assessment is that is very time-consuming. However the results were very encouraging and the teacher felt very positive about the adoption of this kind of forum:

“This kind of strategy is very time consuming. But the final balance is very positive. It helps me to feel more confident about the students’ final grade. I started to know better the students... almost each student (...) It would be very good that after this experience the students would have a similar experience, for example, in other discipline of the second year, because probably we would form better professionals at the end... that is my feeling.”

## CONCLUSIONS

This study aimed at promoting students’ questioning and deep learning about Evolution based on the development of an online discussion forum, “Questions in Biology”.

The content analysis of the online transcripts, considering student questioning, revealed that this asynchronous text-based environment had stimulated the expression of higher-level questioning. Indeed, during the semester, students moved from one questioning approach to another according to particular contexts of the learning environment. It was also possible to associate the formulation of specific questions with phases of cognitive presence, realising that higher-level questioning occurred mainly in the latter phases of the inquiry process, namely the integration and resolution phases. Although in the original model proposed by Garrison et al. (2001:14) the element of “asking questions” was described only as an indicator of the “initiation” and “exploration” phases, in this study we found that other dimensions of questioning could also characterize the higher phases of cognitive presence. These relationships between student questioning and phases of cognitive presence helped us to progress in the understanding of the nature of online interactions that can be supportive of high-level learning, namely in this community of inquiry. However, this could be a particular feature of this online forum, since the purposes of the “Questions in Biology” gave particular relevance to the development of questioning by students. Even though, student questioning may be an important indicator to consider when designing, conducting and assessing online discussion forums with the perspective of higher-order learning.

Student and teacher opinions, revealed during the final interviews, showed the importance of “Questions in Biology” for promoting questioning and higher-order learning. They concluded that “Questions in Biology” enhanced the attainment of

fundamental goals, such as meaningful learning, and the development of some core competencies, such as questioning.

The findings from this study reinforce the assumption that higher-order learning can be developed in online discussion forums (Garrison et al., 2001) when appropriate design and teacher presence are ensured.

A key tool for achieving higher-level questioning and higher-order learning was indeed the teacher's role, here analysed following the concept of teaching presence. We found that the teacher's role was "powerful in triggering discussion and facilitating high levels of thinking and knowledge construction" (Garrison and Cleveland-Innes, 2005:137). Teacher participation in the forum revealed high levels of teaching presence mainly through the roles of "facilitation" and "direct instruction". The "design and organization" role was assumed mainly during the pre-forum activities and was also considered a fundamental aspect for the good development of the discussions. The presence of the three dimensions suggests that teaching presence was effective.

We also believe that assessment and feedback were essential for attaining the fundamental goals: the frequency and quality of student intervention, based on their questioning and higher level learning. There was a constant concern and permanent consideration of students' questions and feedback, and of student-teacher and student-student interactions along the "Questions in Biology". This evidence was continuously used to adapt this strategy to meet student needs as well as the desirable learning goals. The process of designing and implementing this strategy is a continuous one and reflects the introduction of small modifications in teaching, learning and assessment, with emphasis on the importance of formative feedback.

The importance of assessment aligned with the intended learning outcomes leading to better achievements was also strongly emphasised. Since student participation was considered in the final grade, more relevance and engagement was devoted to a meaningful participation, showing very positive results.

Besides the complexity associated with formative assessment within e-learning contexts, all data collected from this forum lead us to believe strongly that "Questions in Biology" represents a good way of formative assessment. This study is also a positive contribution for the adoption of teaching, learning and assessment practices in Higher Education envisaging higher-level learning.

## **ACKNOWLEDGMENTS**

We acknowledge the cooperation of Professor Fernando Gonçalves and his students, without whom this study would not be accomplished, and the financial support of Fundação para a Ciência e a Tecnologia (FCT), Portugal (SFRH/BD/27871/2006).

## REFERENCES

- Arbaugh J. B. and Hwang A. (2006) Does “teaching presence” exist in online MBA courses? *Internet and Higher Education*, 9, 9-21.
- Arbaugh, J. B., Cleveland-Innes, M., Diaz, S. R., Garrison, D. R., Ice, P., Richardson, J. C., and Swan, K. P. (2008) Developing a community of inquiry instrument: Testing a measure of the Community of Inquiry framework using a multi-institutional sample. *The internet and higher education*, 11(3-4), 133–136.
- Anderson, T., Rourke, L., Garrison, D., and Archer, W. (2001) Assessing teaching presence in a computer conferencing context. *Journal of Asynchronous Learning Networks*, 5(2).
- Biggs, J. (1996) Enhancing teaching through constructive alignment. *Higher Education*, 32(3), 347–64.
- Biggs, J. (1999) *Teaching for quality learning at university*. Buckingham: Open University Press.
- Black, P. and Wiliam, D. (1998) Assessment and Classroom Learning. *Assessment in Education*, 5(1), 7-73.
- Black, P. and Wiliam, D. (2009) Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability*, 21, 5-31.
- Boud, D. and Falchikov, N. (2006) Aligning assessment with long-term learning. *Assessment and Evaluation in Higher Education*, 31 (4), 399–413.
- Brown, S. and Knight, P. (1994) *Assessing learners in higher education*. London: Kogan Page.
- Cumming, J.J. and Maxwell, G.S. (1999) Contextualising authentic assessment. *Assessment in Education*, 6(2), 177–194.
- Daly, C., Pachler, N., Mor, Y., and Mellar, H. (2010) Exploring formative e-assessment: using case stories and design patterns. *Assessment and Evaluation in Higher Education*, 35(5), 619-636.
- De Wever, B. Schellens, T. Valcke, M., and Van Keer, H. (2006) Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers and Education*, 46, 6–28.
- Dillon, J. T. (1986) Student questions and individual learning. *Educational Theory*, 36(4), 333-341.

- Dochy, F.J.R.C. and McDowell, L. (1997) Assessment as a tool for learning. *Studies in Educational Evaluation*, 23 (4), 279–98.
- Dori, Y. J. and Herscovitz, O. (1999) Question-Posing Capability as an Alternative Evaluation Method: Analysis of an Environmental Case Study. *Journal of Research in Science Teaching*, 36(4), 411-430.
- Garrison, D. R., Anderson, T., and Archer, W. (2000) Critical Inquiry in a Text-Based Environment: Computer Conferencing in Higher Education. *The Internet and Higher Education*, 2 (2-3), 87-105.
- Garrison, D. R., Anderson, T., and Archer, W. (2001) Critical thinking, cognitive presence, and computer conferencing in distance education. *The American Journal of Distance Education*, 15 (1), 7-23.
- Garrison, D. R., Anderson, T., and Archer, W. (2010) The first decade of the community of inquiry framework: A retrospective. *The internet and higher education*, 13(1-2), 5–9.
- Garrison, D. R. and Cleveland-Innes, M. (2005) Facilitating cognitive presence in online learning: interaction is not enough. *The American Journal of Distance Education*, 19(3), 133-148.
- Gibbs, G. and Simpson, C. (2004) *Does your assessment support your students' learning?* <http://isis.ku.dk/kurser/blob.aspx?feltid=157744> (accessed September 10, 2010).
- Hara, N., Bonk, C.J., and Angeli, C. (2000) Content analysis of online discussion in an applied educational psychology. *Instructional Science*, 28(2) 115-152.
- Heywood, J. (2000) *Assessment in higher education: Student learning, teaching, programmes and institutions*. London: Jessica Kingsley.
- Hofstein, A., Navon, O., Kipnis, M., and Mamlok-Naaman, R. (2005) Developing students' ability to ask more and better questions resulting from inquiry-type chemistry laboratories. *Journal of Research in Science Teaching*, 42 (7), 791–806.
- King, A. (1994) Autonomy and Question Asking: The Role of Personal Control in Guided Student-Generated Questioning. *Learning and Individual Differences*, 6(2), 163-185.
- Kolb, D. A. (1999) *Learning Style Inventory*, Version 3, McBer, Boston, MA.
- Maclellan, E. (2004) How convincing is alternative assessment for use in higher education? *Assessment and Evaluation in Higher Education*, 29 (3), 311–21.
- Marra, R. M., Moore, J. L., and Klimczak, A. K. (2004) Content analysis of online discussion forums: a comparative analysis of protocols. *Educational Technology Research and Development*, 52 (2), 23-40.

Pedrosa-de-Jesus, H. (1991) *An Investigation of Pupils' Questions in Science Teaching*, Unpublished Ph.D. Thesis, University of East Anglia, UK, Norwich.

Pedrosa-de-Jesus, H., Almeida, P., and Watts, M. (2004) Questioning Styles and Students' Learning: Four Case Studies. *Educational Psychology*, 24(4), 531-548.

Pedrosa-de-Jesus, H., Almeida, P., Teixeira-Dias, J. J. C., and Watts, M. (2006) Students' questions: building a bridge between Kolbs' learning styles and approaches to learning. *Education + Training*, 48(2/3), 97-111.

Pedrosa-de-Jesus, H. and 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.

Pedrosa-de-Jesus, H., Teixeira-Dias, J.J.C., and Watts, M. (2003) Questions of Chemistry. *International Journal of Science Education*, 25(8), 1015-1034.

Saadé, R.G. and Huang, Q. (2009) Meaningful Learning in Discussion Forums: Towards Discourse Analysis. *Issues in Informing Science and Information Technology*, 6, 87-100.

Segers, M. and Dochy, F. (2006) Enhancing student learning through assessment: Alignment between levels of assessment and different effects on learning. *Studies in Educational Evaluation*, 32, 171-179.

Swan, K., Richardson, J., Ice, P., Garrison, D., Cleveland-Innes, M., and Arbaugh, J. (2008) Validating a measurement tool of presence in online communities of inquiry. *e-mentor*, 2(4).

Wiliam, D., Lee, C., Harrison, C., and Black, P. (2004) Teachers developing assessment for learning: Impact on student achievement. *Assessment in Education*, 11(1), 49-65.

Zoller, U. (2001) Alternative assessment as (critical) means of facilitating HOCS-promoting teaching and learning in chemistry education. *Chemistry Education: Research and Practice in Europe*, 2(1), 9-17.

### *Correspondence*

Helena Pedrosa-de-Jesus  
Department of Education, University of Aveiro  
Campus Universitário de Santiago  
3810-193 Aveiro  
Portugal  
T: +351 234 372 412  
F: +351 234 370 219  
Email: [hpedrosa@ua.pt](mailto:hpedrosa@ua.pt)