Cognitive engagement and questioning online

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This chapter discusses a range of issues associated with supporting inquiry and deep reasoning while utilising information and communications technology (ICT). The role of questioning in critical thinking and reflection is considered in the context of scaffolding and new opportunities for ICT-enabled scaffolding identified. In particular, *why*-questioning provides a key point of focus and is presented as an important consideration in the design of systems that not only require cognitive engagement but aim to nurture it. Advances in automated question generation within intelligent tutoring systems are shown to hold promise for both teaching and learning in a range of other applications. While shortening attention spans appear to be a hazard of engaging with digital media cognitive engagement is presented as something with broader scope than attention span and is best conceived of as a crucible within which a rich mix of cognitive activities take place and from which new knowledge is created.

Keywords why; question generation; deep learning; reflection; knowledge ecology; intelligent tutoring; scaffolding

1. Introduction

Developments in information and communications technology (ICT) since the invention of the World Wide Web have provided enormous stimulus for innovation in teaching and learning. In practice, there exist numerous trajectories of innovation relevant to e-learning: learning management systems (or virtual learning environments), intelligent tutoring systems, e-portfolio systems, performance support systems, gaming environments, and other related applications have all provided structured approaches to teaching and learning online; mainstream search engines have enabled easy access to an ever-expanding information environment and informal learning; and Web 2.0 applications and services have unleashed the latent social networking potential intrinsic to the 'architecture' of the Internet, enabling knowledge sharing at a scale never previously possible. Despite such rapid advances a number of debates concerning the cognitive impact of mainstream practice have started to emerge in recent years. For example, advocacy of the enabling character of these technologies describes benefits such as facilitation of "multi-tasking" and "extending interaction" [1] while, conversely, critics characterize IT as an "interruption technology" that weakens cognitive focus [2]. Such debates can be seen as a natural cycle and their existence represents a maturing of discourse within the field of e-learning.

Much of the commentary regarding the negative impact of the Web on cognitive ability is not just confined to the discourse on learning with ICT. The emergence of the so-called '24-hour news cycle' suggests that the increased scrutiny by the news media of politicians and their policies creates a bias toward the headline, often hyped, five-second newsbyte as a prime driver of the news. Among other things, this brings the consequence that the ability to communicate a narrative over time is compromised by both the nature of the technology and media cycle itself, both of which are calibrated to exploit short attention spans. It can also be argued that this is happening as a consequence of the amount of information that is readily accessible – information that is now being produced through increasingly diverse channels from increasingly more sources and is yielding increasing layers of complexity for 'knowledge workers' to interact with and create value from [3]. And so, because the production and sharing of knowledge largely depends upon information that is well organized and structured, transforming all this information into knowledge that has operational utility represents a key challenge – that is, if the age we live in is to be accurately characterized as the Knowledge Age.

This chapter picks up these themes as a challenge and is focused on identifying possibilities for the development of ICT scaffolding that supports cognitive engagement through in-session reflection, question-asking, and deep learning. Recent developments in research associated with Question Generation (QG) and Question-Answer (QA) techniques hold much promise for opening up a new frontier for e-learning and intelligent tutoring. In particular, this chapter looks closely at questions initiated by "*why*". Why? There are numerous answers. Unlike the most basic questions of resource discovery and information retrieval (*who, what, when,* and *where*) that are suitably answered by clear-cut facts, *why* questions can be categorized into various types, such as motivational, circumstantial, teleological, or causal – typically demanding an explanation as an 'answer' or response [4-6]. Evidence also suggests that purpose-built ICT support for probing and sustained questioning in e-learning environments appears to be currently undeveloped – despite significant progress in natural language search engine technology [7]. It is therefore arguable that the 'fast-food Google paradigm' of search that delivers an amazing collection of relevant results is still biased toward the 'aboutness' of content, and does not easily probe its explanative potential.

It is clear that e-learning is evolving in both theory and practice. It is also clear that there already exists a range of powerful ICT tools that facilitate learning and the sharing of knowledge. All going well, considered foresight suggests that a Wisdom Age might even develop at some stage in human history [8]. But before that emerges, it will be important that there is some kind of 'completeness' to the learning and knowledge creation tools available. We will soon need to deploy tools that help us manage the *Know-Why, Know-How,* and *Know-If,* as effectively as the *Know-What, Know-When, Know-Where,* and *Know-Who*.

This chapter first discusses issues associated with questioning (in particular, *why*-questioning), its role in learning and its scope of use within ICT-enabled learning environments. This provides the context for discussion on scaffolding facilitated by ICT in which a number of issues are raised concerning the design and implementation of ICT systems. Issues concerning cognitive engagement are presented together with opportunities arising from recent advances in the areas of Question Generation and Question-Answer research.

2. Questioning and Learning

Asking questions is an important foundation of learning [9, 10]. The Inquiry Project at the University of Illinois, a project focused on the advocacy of inquiry-based learning spanning ten years, took an even stronger stance, using as its motto: "learning begins with questions" [11].

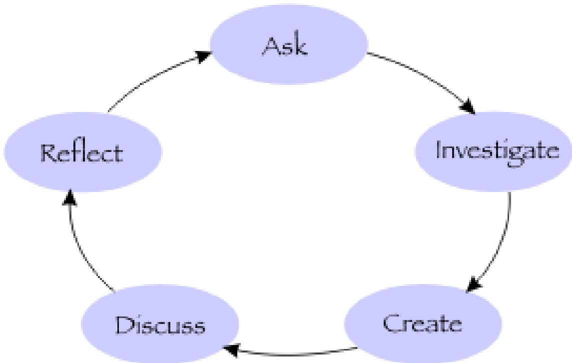

Fig. 1 The primary graphic of the University of Illinois Inquiry Project (2001-2010) representing a virtuous circle of activities associated with inquiry.

While learning can clearly take place without questioning – for example, through repetition and memorization – it is through questioning that reflection, discourse, analysis, and knowledge construction take place. Consistent with this perspective, socio-cultural philosophers of education, Freire and Faundez, have argued for the need for a "pedagogy of asking questions" that gives emphasis to the questioning process as something valuable in itself, where the 'answer' may not even be relevant: "Thinking about questions that may not always or immediately arrive to an answer are the roots of change" [12]. More recently, Thomas and Seely Brown identify the emergence of a "new culture of learning" as a consequence of innovation with ICT and make the argument:

> We propose reversing the order of things. What if, for example, questions were more important than answers? What if the key to learning were not the application of techniques but their invention? What if students were asking questions about things that really mattered to them? [13]

What if, indeed! According to the 1944 Nobel Laureate in Physics, Isidor Rabi, when asked how he came to be a scientist he answered as follows:

> My mother made me a scientist without ever intending it. Every other Jewish mother in Brooklyn would ask her child after school, 'So? Did you learn anything today?' But not my mother. She always asked a different question, 'Izzy,' she would say, 'Did you ask a good question today?' That difference – asking good questions – made me a scientist. [14]

2.1 Socratic Questioning

The art of asking questions that help elicit the truth, reveal misconceptions and assumptions, or just the discovery of richer perspectives was most famously developed by Socrates as a pedagogical technique nearly twenty five hundred years ago [15,16]. For Socrates, dialogue was paramount in revealing poor argumentation and prejudice; while probing questions help cultivate reasoning skills. Much of the more contemporary literature on scaffolding can be shown to have roots in what is now termed 'Socratic Method' or Socratic Questioning' [17-22]. In some ways and somewhat ironically, implementation of the Socratic Method can be seen as blurring the boundary between the roles of teacher and mentor. Although Socrates succumbed to transgressing the law and was convicted of corrupting the young he was regarded by many of his peers, as well as countless scholars since, as being considerably wise. His approach is clearly durable and the close interdependency of questioning and dialogue that is a prominent characteristic aligns closely with the contemporary approach of Figure 1.

So, what distinguishes Socratic questioning from other questioning? According to Paul and Elder "Socratic questioning is *systematic, disciplined,* and *deep* and usually focuses on foundational concepts, principles, theories, issues, or problems." [23] However, *curiosity* is also an essential requirement for it to proceed effectively – for the simple reason that an inquisitive mind is voluntary. The roots of the critical thinking movement in education can likewise be traced to Socrates, for its goals of clarity of thought and the pursuit of truth are similar, although critical thinking is more explicit about the importance of 'metacognition', or thinking about thinking. From a pragmatic perspective, Paul provides a useful classification of Socratic questions as summarised in Table 1 [24]. In subsequent work, Paul and Elder define three categories of Socratic Questioning: "spontaneous, exploratory, and focused" [25]. These 'categories' are better described as modes of delivery that together represent a pragmatic pedagogical perspective aimed at cultivating and maintaining student interest. Importantly, Paul and Elder have found that while questions can be classified, the *practice* of effective Socratic Questioning demonstrates that context must always shape the process – hence, any prescriptive lists of questions will invariably falter.

Table 1 Adaptation of Paul's classification of the Six Types of Socratic Questions [24]

Type of Question	Examples
Questions that require clarification	*Why did you say that?* *What does that mean?* *How does this relate to your earlier statement?*
Questions probing assumptions	*Can that statement be validated?* *What beliefs are assumed here?* *Might there be other agendas involved by those who are making these claims?*
Questions probing reasoning and evidence	*What do you think the causes are? And why?* *Is there any evidence or facts that support this?* *How complex is the issue?*
Questions probing perspective	*Is there another way to look at this?* *What are the arguments to the contrary, if any?* *Can you provide an overall rationale?*
Questions probing implications	*What consequences can you see arising?* *Can a generalisation be made?*
Questions about the question	*Why is this question relevant?* *What does this mean in practical terms?*

Having endured a considerable test of time Socratic Questioning therefore represents an important consideration in the design and implementation of ICT systems that aim to support learning. It also represents a challenge for any automated approaches given its highly contextual and interactive requirements.

2.2 Asking why

If *understanding* is the goal then asking *why* is arguably one of the most commonplace acts of inquiry. 'Why' questions are characteristic of the early years of language and cognitive development and it is certainly typical for a young child to ask *why* questions in order to understand the world better [9, 26]. Commenting on Piaget's seminal work in the area of developmental psychology Otero adds that there is a connection between *cognitive obstacles*, learning, and the need to ask *why*:

> According to Piaget, a conception of the world where chance plays a very limited role explains why children from approximately 3 to 7 years of age ask so many *Why* questions. In contrast to adults, who rely on chance and contingency to explain many phenomena, children believe in a highly predictable world where chance plays a lesser role. Assuming there is very limited room for chance in their mental representations of the world, many events and states that are not problematic for adults turn out to be full of obstacles for children. [27]

For older children as well as young and older adults *why*-questioning remains important throughout life in a multiplicity of contexts – such as social conversations, eliciting explanations, scientific analyses, legal proceedings and formal education [28]. Yet, it is the case that the tools that facilitate inquiry on the Web – despite being extraordinarily powerful – are overwhelmingly configured toward responding to queries in the form of subject keywords and phrases. Why is this so? One explanation is that the most basic questions of resource discovery and information retrieval are instigated by the 'primitives' *who, what, when,* and *where* [4]. All such primitives are associated with factual information; they describe facts, persons, events and places, and therefore provide straightforward information for search engines to gather and return as results. But if we are concerned with processes of teaching and learning then there are other important questions to consider. Learning, education and training involve more than the retrieval and exchange of information and content that is well described by facts associated with questions of *who, what, when,* and *where*. Clearly, some of these questions will be instigated by *how* and *why*.

The problem with *why*-questioning is that layers of complexity are introduced making it considerably more challenging to build ICT systems that can parse information to adequately to support it. *Why*-questioning often requires further contextual information to satisfactorily provide an 'answer' (e.g., *why are flights grounded today?* the search engine may be configured to look at *where* the questioner is located as well as the time of day and infer a set of results, but this may not be the case). *Why*-questioning raises questions of motivation and purpose (e.g., *why did Obama run for Presidency of the United States?*) in which there is likely to be no clear-cut answer. *Why*-questioning often involves consideration of causality (e.g., *why is cancer a difficult disease to cure?*). In some cases, a *why*-question may point to a straightforward scientific answer (as in *why does salted water boil at a higher temperature to pure water?*) but in others will introduce politics and opinion (as in *why are the Israelis and Palestinians caught up in such intractable conflict?*). *Why*-questions can also touch upon wonderment and existential angst (e.g., *why can't scientists explain what caused the big bang?* and *why do we need to sleep?*). Importantly, in most cases *why*-questioning demands an *explanation* or *rationale* as an adequate response.

2.3 Classifying *why*-questions

Researchers from a diversity of fields – such as computational linguistics, discourse analysis, psychology, artificial intelligence, knowledge management, and intelligent tutoring – have recognised these issues and analysed *why*-questions for many decades [4-7, 27, 29, 30]. The fact that there is such a diversity of researchers involved immediately indicates the cross-disciplinary nature of the challenge.

Another dimension to this challenge arises because of the versatility of the word *why* itself. Not only is the word *why* commonly found in questions but also within a range of other linguistic expressions. From a grammatical perspective it can function as an interrogative (simply as *Why?*), an adverb (as in *Why do we sleep?*), as a pronoun (as in *There is no reason why she shouldn't attend*), as a noun (as in *He provided an analysis of the question why*), and as an interjection (as in *Why, you're crazy!*).

One way of classifying *why*-questions is from a linguistic perspective, as in Table 2.

Table 2 Common forms of *why* questions*

Why do/does/did ...
Why is/are ...
Why can ...
Why then ...
Why will ...
Why has/have ...
Why may/might …
Why should …
Why could …
Why [noun / verb / phrase / proposition]

* Assumes associated negative counterparts (*Why don't?* etc.)

In another approach, Evered details a "typology of explicative models" in which the explanatory function of responses to *why*-questions is classified into three classes of explanation:

Causal: (*Why E? Because C* (C= cause));
Teleological: (*Why E? In order to P* (P = Purpose)); and
Gestaltic: (*Why E? For these reasons, R* (R = Reasons)) [6]

Evered's classification provides a succinct framework; however, the challenge of utilising this in the context of teaching and learning facilitated by ICT is yet to be realised.

More recently, Verberne has presented an analysis on *why*-questioning focused on linguistic structures and components that can inform the design of effective automated question-answering (QA) systems [5]. QA research had its beginnings in the field of information retrieval (IR) during the mid-1990s and has since developed a significant and mature discourse [30]. Verberne's classification identifies four kinds of *why*-questioning after close discourse analysis and "distinguish[es] the following subtypes of reason: cause, motivation, circumstance (which combines reason with conditionality), and purpose" [5]. However, Verberne shows that while such classifications can be helpful they are not sufficient – certainly not for the purpose of informing the design of automated ICT QA systems. Importantly, despite her expectation that algorithms focused upon reasoning would likely provide most guidance on the design of any effective automated answering system, her work on linguistic structure and relation reveals that "elaboration is more frequent as a relation between a *why*-question and its answer than reason or cause". This key finding has helped Verberne develop a number of related algorithms informed by IR and Natural Language Processing (NLP) techniques that together demonstrate an effective approach to ICT systems design for answering *why*-questioning [5]. Despite achieving close to 60% effectiveness in answering *why*-questions, and what would seem to be respectable results, Verberne concludes:

> high-performance question answering for *why*-questions is still a challenge. The main reason is that the knowledge sources that are currently available for NLP research are too limited to capture the text understanding power that is needed for recognizing the answer to an open-domain *why*-question. Since this capability is problematic for machines but very natural for human readers, the process of *why*-QA deserves renewed attention from the field of artificial intelligence. [5]

Such a statement masks the progress already made; however, if we consider the discussion on Socratic questioning in which questions are not regarded in isolation but as part of a sequence of other questions all contextually related then Verberne's conclusion is probably an understatement! Automating a Socratic interrogation seems like it will take more than renewed attention from the field of artificial intelligence.

2.4 Explanation as a response

There is a flipside to the linguistic versatility of the word *why*: it can also be perceived as semantically ambiguous. This ambiguity contributes to some extent to the requirement that adequate responses to *why*-questions therefore either lead to further dialogue or need to be explanatory. This becomes a complex task for ICT systems developers.

Early developments in artificial intelligence (AI) during the 1970s produced rule-based systems (based on methods such as 'if-then' tree chaining) that were capable of delivering crude explanations as responses to queries on a specific knowledge-base that involved both *how* and *why* [32]. Because of the multiplicity of question types it was soon recognised that question classification schemes were required [33]. These classifications have been improved since then, as described above, and now inform Question Generation (QG) research [7]. However, as Gilbert points out, it soon became apparent within the AI community that it was just as fruitful to classify *explanatory answers* rather than the questions. These early systems used matrices that provided a small set of explanation types from which to build plausible answers [32]. They might seem crude now but they also can be seen as initiating an important trajectory in ICT research and development.

Since these early days much has been achieved, not only in AI and question-answering but also in the related area of search engine technology. Anyone who uses the Web will be well-acquainted with the awesome power of the sophisticated algorithms that drive Google and other search engines. Despite these accomplishments Google and other mainstream search engines do not yet deal effectively with explanatory content. Some success in this area is only beginning to emerge as a result of developments in Natural Language Processing (NLP). For example, NLP underpins niche search engines like PowerSet [34] and TrueKnowledge [35], and while still in early development, are demonstrating delivery of explanatory material to both *how*- and *why*-questions.

It is also important to emphasize here that explanatory content on the Web is not necessarily text-based and therefore does not have explicit reasoning embedded in it [36]. Ever since multimedia emerged as the mainstream of educational technology development in the years prior to the invention of the Web the education community has benefited tremendously from easy access to powerful visual simulations that explain processes or complex relationships. This is also very true for all sectors of the economy, whether it is benefiting medical practitioners, stockbrokers, meteorological bureaus or real estate sales.

To summarise this discussion on questioning and learning it is appropriate to consider why the preceding discussion on *why*-questioning is so important. In short, it represents a frontier that is informed by research across a diversity of disciplines – a frontier that will likely be chartered with ICT but be informed by techniques of inquiry developed by Socrates and research into the NLP as well as by the ever-expanding resource of visual-based materials. It is very much a work-in-progress. Importantly, it signals an opportunity for research and development of ICT tools that promote reasoning and deep learning. If we are concerned with enhancing the scope and effectiveness of teaching and learning using ICT then there are other important questions to consider beyond the *who, what, when,* and *where* of content for learning. Clearly, questions instigated by *why* achieve this as they are concerned with inquiry and the explanatory nature of content.

3. Scaffolding and ICT

3.1 Scaffolding learning – the traditional view

In the context of educational theory and practice the term '*scaffolding'* has been typically used to indicate assistance provided by the teacher to the student in constructing knowledge (conceived initially with an 'adult to child' emphasis) [18, 19]. Over time it has evolved in meaning to also include assistance provided by peer learners in the development of understanding and the construction of knowledge [20-22]. Thus, scaffolding is concerned with techniques and tools used to assist in the development and maturation of conceptualisation associated with learning. In other words: "This process of scaffolding is much like the traditional definition of scaffolding as a temporary support system used until the task is complete and the building stands without support" [22].

Following this traditional view and the work of Applebee [31], Foley lists five criteria for effective scaffolding:

1. *Student ownership of the learning event.* The instructional task must allow students to make their own contribution to the activity as it evolves.
2. *Appropriateness of the instructional task.* This means that the tasks should build upon the knowledge and skills the student already possesses, but should be difficult enough to allow new learning to occur.
3. *A structured learning environment.* This will provide a natural sequence of thought and language, thus presenting the student with useful strategies and approaches to the task.
4. *Shared responsibility.* Tasks are solved jointly in the course of instructional interaction, so the role of the teacher is more collaborative than evaluative.
5. *Transfer of control.* As students internalize new procedures and routines, they should take a greater responsibility for controlling the progress of the task such that the amount of interaction may actually increase as the student becomes more competent. [20]

These five considerations represent good constructivist pedagogical principles that are applicable in any formal learning environment, whether ICT-enabled or not. Of course, such principles do not represent the last word on good pedagogy and research by Kapur (2006-2010) has shown conclusively that "engaging students in solving complex, ill-structured problems without the provision of support structures can be a productive exercise in failure" [37]. In reaching such a conclusion Kapur takes a long view beyond the experience of failure itself to recognising the benefits of acquiring skills of adaptability and flexibility during adversity. Thus, there are many circumstances in which leaving students to fend for themselves without structure or support may be better than too much scaffolding. With this caveat in mind it is now useful to consider the impact of ICT on the conceptualisation and implementation of scaffolding.

3.2 Scaffolding learning – the role of ICT

With ICT now foremost in the toolset available for teaching and learning a range of new opportunities for scaffolding student learning are available [7, 38-45]. Yelland and Masters go further and argue that:

> in computer contexts extended conceptualisations of scaffolding are needed in order to gain greater insights into teaching and learning processes. Our work has revealed that traditional forms of scaffolding, based on the "expert's" view of how the problem should be solved, need to be modified in order to accommodate the child's perspective and that three different types of scaffolding which we refer to as *cognitive*, *technical* and *affective* can be conceptualized. [46]

In a similar way, McLoughlin and Lee argue that the practical meaning of scaffolding has now "expanded to include learner selected assistance, peer interactions, or could be embedded in technology" [48]. This observation is supported by the argument that "digital literacies" and "self-regulated learning" require scaffolding just as much as "independent learning".

Thus, for about two decades Computer Supported Collaborative Learning (CSCL) has been used effectively as a way to utilise the resources of an online community as a means to scaffold student learning [44]. CSCL provides an effective platform for both synchronous and asynchronous discussion and, as such, accommodates the time required for participants to reflect and then document reflections for input into discussions with others. Clarkson and Brook place emphasis upon peer collaboration using online forums and argue that ICT acts as a mediator in expanding the domain for cognitive development, or what Vygotsky [19] referred to as the "zone of proximal development" [40]. In promoting good practice in 'e-moderating' online discussions, Salmon advocates interventions such as 'weaving' discussion threads together to stimulate student engagement – such an activity, while not impossible without ICT, is one that ICT has made compellingly easy [45]. From an even broader perspective, Wenger *et al.,* have coined the term "technology stewardship" that incorporates the function of scaffolding in the wider context of the development and sustainability of online "communities of practice" [47]. In all these examples, interaction with others is prominent – and this approach has continued to gain momentum with the proliferation of Web 2.0 applications that foster online social engagement and collaboration. Moreover, as McLoughlin and Lee point out "Scaffolding need not be teacher directed, and current social software tools can be used in ways that address learner centred concerns for self-managed learning and control (for example, e-portfolios)” [48].

In other approaches that are focused primarily on capabilities of the technology, Bell and Davis (2000) highlight the effectiveness of a guidance and prompting system as scaffolding for the development of scientific argumentation and general reflection [38]. Intelligent tutoring is also a field where the development of technological capability is of prime concern; however, as researchers involved in Project LISTEN at the Massachusetts Institute of Technology found a decade ago, the design of intelligent tutoring systems would be improved if they could augment cognitive support with “emotional scaffolding” [49].

3.2.1 Automated Question Generation

While it is recognised that human tutoring still outperforms automated systems for progressing large units of study the development of intelligent tutoring systems (ITS) has progressed considerably since project LISTEN [50]. ITS have been used effectively in the development of reflective skills such as planning, questioning, explaining, and criticizing – primarily because they provide an effective means for practice [50, 51]. One area of research that is pertinent to this chapter is automated question generation (QG). In identifying a niche in which ITS might perform better than human tutors Graesser *et al.,* have observed:

> Most teachers, tutors, and student peers do not ask a high density of deep questions … so students have a limited exposure to high-quality inquiry. There are a few role models in school environments through which students can learn good question asking and answering skills vicariously. This situation presents a golden opportunity for turning to technology to help fill this gap. [51]

In earlier work, Graesser *et al.,* concluded:

> Training learners to ask deep questions (such as *why, why not, how, what-if, what-if-not*) is desired if we want the learner to acquire difficult scientific and technical material that taps causal mechanisms. The comparatively shallow questions (*who, what, when, where*) are often asked by students and instructors, but these shallow questions do not tap causal structures … [also] One of the key predictors of deep questions during inquiry is the existence of goals, tasks, or challenges that place someone in cognitive disequilibrium. Learners face cognitive disequilibrium when they encounter obstacles to goals, anomalies, contradictions, disputes, incompatibilities with prior knowledge, salient contrasts, obvious gaps in knowledge, and uncertainty in the face of decisions. [7]

Thus, one of the trends emerging from the QG community is the development of technology systems that do two things: (1) training learners how to construct good questions that promote deep reasoning skills; and (2) constructing well-formed questions from collections of content. This latter activity has significant implications for how ITS might be deployed for navigating explanatory content and represents a significant alternative to the keyword and key phrase-driven approach of the mainstream search engines.

To sum up: advances being made within the Question Generation community signal new opportunities for ICT-enable teaching and learning through the development of scaffolding that spans both the cognitive and the technical domains. It would also seem that some forms of scaffolding will always be better performed by humans (such as providing emotional support) while other forms will likely excel if embedded in the technology platform itself (including systems other than intelligent tutoring systems, such as learning management systems, electronic textbooks, e-portfolio systems, or Web 2.0 applications).

4. Cognitive Engagement

There exists an extensive body of literature on the subject of cognitive engagement from diverse fields such as anthropology, psychology, cognitive science, education, information systems, human-computer interaction, augmented cognition, and biometrics in marketing [52-58]. Much of it is grounded in scientific research. There is also a growing body of commentary concerned with the detrimental effects of the Internet on our abilities to stay focused – describing it as “the enemy of insight” [59], “the greatest detractor to serious thinking since television” [60], and an “ecosystem of interruption technologies” [61]. For Carr, one of the luminaries credited with first articulating the benefits and inevitability of “cloud computing”, the Internet is:

> the single most mind-altering technology that has ever come into general use … when we go online, we enter an environment that promotes cursory reading, hurried and distracted thinking, and superficial learning … The Net’s cacophony of stimuli short-circuits both conscious and unconscious thought, preventing our minds from thinking either deeply or creatively. [2]

A number of questions arise from this development: *does this situation represent a transitional condition or is it a warning that the consequences, yet to ripen, might be mass plagues of dementia?* And more pertinent to the theme of this book: *what does this mean for online learning?*

There are no simple answers, although the literature on cognitive engagement points to the fact that whether pedagogical techniques are used or not, interest and motivation of the individual learning are key factors. This is easy to say and not always easy to measure as motivation is multi-faceted and complex to understand [62, 63]. But as Corno and Mandinach have shown, “self-regulated learning” represents the highest form of cognitive engagement in classroom contexts [55, 56]. So, amongst all the alerts and distractions of being online, it would seem that new tools and new scaffolding techniques will be required in order to optimise the opportunities for learning using ICT so that learners can better regulate their learning. Useful findings are already emerging from Question Generation research showing that students will perform better after being exposed to sessions of deep reasoning and that, contrary to expectation, exposure to text-based deep reasoning appears to provide better stimulus than spoken deep reasoning [64]. This finding probably points to the fact that text provides more opportunity for reflection. It is also consistent with observations in concerning the value of computer-mediated communication as it was first called in the mid-1990s [65].

Requirements for maintaining focus, as well as interest and motivation, have implications particularly for the design of purpose-built learning environments such as learning management systems, e-books, e-portfolios, virtual learning environments, and intelligent tutoring systems (in other words, platforms that are somehow *contained* within certain boundaries). In the case of *Second Life*, studies have shown that role-playing in immersive virtual environments can stimulate thinking, problem solving, and learning [53]. This is also true for standalone services, applications, and games that support learning, although in many cases they are already designed effectively to capture attention and, as Carr [2] argues are already calibrated for short attention spans.

It seems clear then, that the domain of (potential) cognitive engagement is both expanded and bombarded by the proliferation of innovations in ICT. A question that arises here is: *what are the boundaries of cognitive activity?* Drawing from both Anthropology and Cognitive Science Hutchins [66] argues that while common sense decrees that cognitive activities are considered to reside within an individual’s head there are also “cognitive properties of a system”. In this case, a system “comprises all the actors within a setting, their interactions with one another, and the technical and cultural tools they interact with.” Following this, Crawford *et al.,* have developed a “framework [that] posits a holistic view of the classroom as a highly integrated system of actors, tools, and content engaged in individual and social learning activities over time [56]. There are many moments and circumstances in which cognitive engagement therefore takes place, some of which may not be online as such but may arise during another activity (such as reflection or planning) *as a consequence of being online*. Crawford *et al.,* therefore introduce the term *cognitive density* “to describe the aggregate level of students’ (cognitive, social, and affective) engagement with learning materials and thinking, their progress in learning, their communication, and their use of time”. However, their conclusion that “increasing cognitive density is a general approach to improving student learning and is independent of a specific pedagogic intervention” [56] appears to be at odds with the preceding discussion on the negative impact of excessive cognitive demands. One thing is clear – more research in this area is required if we are to successfully align emerging capabilities of ICT with optimised teaching and learning and in this process achieve better understanding.

5. Conclusions and future work

Innovation in ICT and the consequences that it brings to teaching and learning is not only relentless but it appears to be evolving at an increasing pace. While there is often an exciting and enabling upside with every new technological development and device there brings a new challenge – to better understand the consequences and implications, both positive and negative. The increasing prospects of major cyber-crime should be sobering enough.

Clearly, *inquiry* and *reflection* are key elements of learning. They need to be nurtured appropriately in the design of learning environments and in the conduct of teaching that align with contemporary realities. Cognitive engagement with ICT is much more than a question of attention span and is best conceived of as a crucible within which a rich mix of cognitive activities take place and from which new knowledge is created. If the rich information and one-click knowledge-sharing world is losing its balance through bloating and excessive interruption and search-and-distract behaviour then strategies need to be in place to re-balance it.

If “today’s weirdness is tomorrow’s reason why”, as Hunter S. Thompson once famously quipped [67], then developing better tools to reason and understand *why* should be a smart move now.

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