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Scaffolding for Integrated Reflection

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Abstract: This paper presents some theoretical perspectives that might inform the design and development of information and communications technology (ICT) tools to support integrated (in-session) reflection and deep learning during e-learning. The role of *why*-questioning provides the focus of discussion and is informed by the literature on critical thinking, sense-making, and reflective practice, as well as recent developments in knowledge management, computational linguistics and automated question generation. It is argued that there exists enormous scope for the development of ICT scaffolding targeted at supporting reflective practice during e-learning. The first generations of e-Portfolio tools provide some evidence for the significance of the benefits of integrating reflection into the design of ICT systems; however, following the review of a number of such systems, as well as a range of ICT applications and services designed to support e-learning, it is argued that the scope of implementation is limited.

Keywords: ICT, e-learning, pedagogy, critical thinking, explanation, reflection, question generation, question-answering, QG, Q-A, storytelling

Introduction

Prior to the invention of the World Wide Web and the subsequent proliferation of information and communications technologies (ICT) that support learning, education, and training (LET), the concept of 'scaffolding' was used to describe the support and guidance provided by a teacher to a student to assist in conceptualizing problems and constructing knowledge. It was conceived initially with an 'adult to child' emphasis [33, 39]. It has now evolved in meaning to also include assistance provided by peer learners and ICT systems in the development of understanding and the construction of knowledge [5, 10]. In both meanings, scaffolding is therefore concerned with techniques and tools used to assist in the development and maturation of understanding associated with learning. Furthermore:

> 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. [16]

Thus, once understanding and/or knowledge has been acquired, the scaffolding becomes redundant. In the case of ICT, however, it would appear that scaffolding may be re-used for multiple purposes. A search engine that offers options of conceptual categories that refine an initial search query provides a generic example through its clustering of concepts and terms that are semantically related.

Despite rapid advances in ICT and its application in LET, however, commentary concerning negative cognitive impact has begun to emerge in recent years. For example, Carr (2010) characterizes IT as an "interruption technology" that weakens cognitive focus. In substantiating this Carr says:

> The Internet…wasn't built by educators to optimize learning. It presents information not in a carefully balanced way but as a concentration-fragmenting mishmash. The Net is, by design, an interruption system, a machine geared for dividing attention … What we are experiencing is, in a metaphorical sense, a reversal of the early trajectory of civilization: we are evolving from being cultivators of personal knowledge to being hunters and gatherers in the electronic data forest. [4]

Such a characterization may well describe mainstream usage of the Web but it doesn't describe all usage scenarios, particularly those learning environments that are designed to contain interaction with specific content and peers. For example, the development of e-portfolio systems that specifically support reflective learning in personalized learning environments represents an important trend. Intelligent tutoring systems and learning management systems represent other, more established, examples.

Following on, this paper presents a theoretical perspective that is focused on how ICT might further "optimize learning" through supporting integrated (in-session) reflection and deep learning during e-learning. The role of *why*-questioning provides the focus of discussion and is informed by the literature on critical thinking, sense-making, and reflective practice, as well as recent developments in knowledge management, computational linguistics and automated question generation.

1. Questioning, Storytelling, and Explanation

Questions initiated by *who, what, when, where, how,* and *why* belong to a set sometimes referred to as the "journalists' questions" [38]. Why this label? For the simple reason that answers to these questions help create a story. Without answers to *who, what, when,* or *where* there is no news and nothing to report. There are no facts, and there is no information. When answers to *who, what, when,* and *where* are supplemented with answers to *how* and *why* then the storytelling creates interest.

These 'primitive' questions can also be considered in a number of other ways, based upon function. From an information science perspective *who, what, when,* and *where* collectively form what can be termed the "primitives" of text-based information retrieval because they assist in the retrieval and discovery of factual information [8, 17]. As such, they form the basis of most metadata schemas designed to describe and manage information resources, whether in physical libraries or in the digital domain. This is because they define the core aspects of provenance.

Stories of the form "*once upon a time in a far off land there was an ogre who lived under a bridge"*, typically contain the four primitives in the first sentence; although, on close analysis a rich complexity is established as a number of facets to "*what*" can be discerned. Anyone who has ever told such a story will also know that being interrupted by a young child with questions of *how* and *why* is part of the process of the child making sense of things.

During the last decade the evolution of Knowledge Management has been described as a shift from a managerial discourse driven by a theory of reduction toward a richer academic discourse and organizational intervention informed by complexity and theories of emergence [27, 37]. During this time it is also true that *storytelling* has become recognized as an important tool for sense-making and sharing knowledge [6]. Of course, storytelling has its roots long before human societies became literate. In the case of indigenous Australians, often through song, it was a primary means of preserving cultural and environmental knowledge from one generation to the next for many thousands of years [7, 30].

Despite storytelling being advocated as a useful component of e-learning [21] and an artifact of reflection it is not the central focus here. More importantly is the role of *why*-questioning during learning. More than any of the other 'primitive' questioning, *why*-questioning requires an explanation or a rationale as an adequate response – that is, information coupled with reasoning. While explanation and rationale are often part of a good story they are not necessarily its essential or driving components. Thus, it is *explanatory* content which is of prime interest here as distinct from descriptive content. The question that follows is: *what ICT scaffolding opportunities might be designed into systems explicitly built to support* why*-questioning?*

2. Critical Thinking, Pedagogy, and Reflective Practice

While 'critical thinking' and 'reflective practice' can be defined in different terms and there exists a significant body of literature associated with each, it is assumed here that they share much in common and both are generally understood as a positive influence upon learning. Neither activity takes place without some kind of critical attention or attitude of enquiry; in many situations they work together; and, *why*-questioning is common to both.

Critical thinking is a cognitive process that is often associated with enquiry and analysis and the role of *why*-questioning within formal LET contexts has long been recognized as a key component in its development [22, 23, 36]. Enquiry based learning is facilitated when the learner makes sense of some content through interpretations and judgments. Despite this, however, there does not appear to be one commonly accepted theoretical approach to the conceptualization of critical thinking within the Philosophy of Education with ongoing debates concerning the roles of reason versus skill [1, 26, 34]. In Psychology, the debate is to do with whether critical thinking is an aptitude or a skill [19]. Resolution of such debates is not crucial to the theme of this paper – what is important is how critical thinking might be facilitated. Traditionally, this will be understood to be the role of pedagogy; but with advances in ICT and learning design it is likely that purpose-built tools will also serve this role.

In a similar way, the discourse on reflective practice and its epistemological roots reveals some tensions around 'learning through doing' and 'learning about' and the appropriateness and timing of reflection on the job [31]. When considered in a holistic sense, reflection is a mix of cognitive processes that can be quite complex, involving much more than recall and comprehension or the composition of a journal entry – involving discernment, objectivity, identification of facts and issues, checking, reconciliation, summarization, synthesis, and pattern recognition, etc. In situations that require domain-specific knowledge then it is also likely to involve sophisticated cross-referencing with an established knowledge base [35]. But whether it is during internship or the context of continuing professional development it is now standard practice for practitioners (from professionals to trainees) to engage in a critical examination of outcomes of a learning experience. The mainstream institutionalization of this as an activity (such as keeping a personal journal) that takes place *after* a learning experience represents, however, only a subset of the potential range of cognitive tasks required for integrated reflection.

The challenge of achieving integrated (in-session) reflection, whether the session is a unit of e-learning or teaching or some other vocational activity, will ultimately be determined by the context. Where it is appropriate for scaffolding to assist in the process then the design of that scaffolding will be an important factor in determining the outcome.

Dedicated software already exists that could be used effectively for e-learning – for example, Rationale™ is software specifically to enhance student abilities in forming rational arguments and reasoning skills through identifying fallacies or weakly formed arguments within existing texts. Its website contends:

> Rationale is the most effective software tool for building students' critical thinking skills. It can be used throughout all curriculum programs at tertiary, secondary and primary levels of education … [and] when someone states a contention, we usually ask "why?" Critical thinkers want to know the reasons for and against the contention before they form a judgment. [25]

Combining the threads of the discussion above with that of the preceding discussion regarding questions, Thomas and Seely Brown (2011) identify the emergence of a "new culture of learning":

> 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? [28]

This proposition aligns neatly with recent advances in computational linguistics and automated question generation, both of which provide new opportunities for the design of tools to support e-learning discussed in the next section [8, 14].

3. Linguistic and Computational Perspectives

3.1 Linguistic Versatility

The versatility of the word '*why*' is clearly evident from the fact that it is commonly found in questions as well as 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 semantics associated with why*), and as an interjection (as in *Why, you're crazy!*). This versatility provides the basic rationale for why it might be useful to classify *why*-questioning [14]. This linguistic versatility has the implication that any computational modeling of textual content that contains *why* will need to consider carefully the broader textual context.

Evered (2005) provides an analysis in which the explanative function of responses to *why*-questioning is categorized according to 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)) [8].

Closely aligned with this classification is the work of Verberne (2010) whose analysis on *why*-questioning is focused on linguistic structures and components that can inform the design of effective automated question-answering (QA) [32]. QA research had its beginnings in the field of information retrieval (IR) during the mid 1990s and now has a significant and mature discourse [18]. Verberne's classification identifies four kinds of *why*-questioning after closer discourse analysis and "distinguish[es] the following subtypes of reason: cause, motivation, circumstance (which combines reason with conditionality), and purpose" [32]. However, Verberne shows that while such classifications can be helpful they are not sufficient. Importantly, despite her expectation that algorithms focused upon reasoning would likely guide 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 [32]. Despite achieving close to 60% effectiveness in answering *why* questions, 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. [32]

NLP has also been important in the research and development associated with natural language search engines such as PowerSet [24] and TrueKnowledge [29]. More recently IBM has led the DeepQA project with its smart computer named "Watson" [32]. But again, there are limits to its effectiveness of answering *why*-questions:

> The expectation is that if there is a good explanation out there Watson can discover, score, and even chain levels of explanation together. However, inferring how and why answers that require deeper thinking may represent a level of intelligence that requires capturing knowledge that is much more difficult to automatically learn. [9]

Will these advances also deliver new opportunities for integrated reflection during learning? Only time will provide an answer to this question for now; however, there is no reason why the design of ICT could not anticipate such developments given that innovation takes place in multiple domains in parallel.

3.2 Question Generation

Possibly one of the more promising areas of research currently underway that might yield implementation opportunities for ICT tools that might support *why*-questioning is the field of Question Generation (QG). As Thomas and Seely Brown suggested above [28], and others such as Freire and Faundez (1989) argue [36], it may well be that the framing of questions is more productive for learning in an information-rich context than the actual answers. Thus, Freire and Faundez also argue 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" [11].

As a consequence of innovations in ICT, however, the volume of accessible information is at a scale never previously seen with information now being produced through increasingly diverse channels from increasingly many more sources and yielding potentially increasing layers of complexity. Thus, Graesser, *et al.,* (2008) make the following observation:

> For the first time in history, a person can ask a question on the web and receive answers in a few seconds. Twenty years ago it would take hours or weeks to receive answers to the same questions as a person hunted through documents in a library. In the future, electronic textbooks and information sources will be mainstream and they will be accompanied by sophisticated question asking and answering facilities. As a result, we believe that the Google generation is destined to have a much more inquisitive mind than the generations that relied on passive reading and libraries. The new technologies will radically transform how we think and behave. [12]

Learning how to ask good questions is clearly very important in both teaching and learning. In highlighting this, the 1944 Nobel Laureate in Physics, Isidor Rabi, once responded to a question as to how he came to be a scientist, 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. [2]

Following this line of argument, Graesser *et al.,* assert that:

> 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. [13]

Through developing intelligent tutoring systems and tools that can create well-formed questions from collections of relevant content it seems likely that new opportunities are not far away for ICT that is better able to support *why*-questioning, and, as a result, support integrated reflection during e-learning.

4. Related Work

There are numerous examples of work that has some synergy with the theme of this paper. For example, the Inquiry Project at the University of Illinois is a project focused on the advocacy of inquiry-based learning and it uses the motto: "learning begins with questions". Of course, no motto covers all scenarios and while learning can clearly take place without questioning – for example, through repetition and memorization – it is through questioning that reflection, discourse, and knowledge construction takes place.

In the area of e-portfolios used in LET much has been said and documented about the key role that reflection can play in assisting ongoing learning and professional development [15]. An initial review of practice, however, reveals that while a designated space for documenting and collating personal reflections is a typical design feature of most e-portfolio systems very little exists in the way of tools that stimulate reflection, apart from question prompts and templates. Thus, apart from enabling personal journalism through blogs and template approaches to writing, scaffolding tools within e-portfolio systems that encourage the actual process of reflection appear to be under-developed.

As a consequence, Wang (2009) proposes "an ontological model that specifies a generic organizational structure of eportfolios in the integrated reflection context" [35]. In this model reflection features as a dominant ontological category within a structure that includes learning subject, learning objectives, learning objects, assessment instruments, and reflection query. Wang's conception, 'integrated reflection' is facilitated by 'active learning' but represent a challenge for widespread deployment.

Looking back to older theoretical models, Bloom's taxonomy [3] of educational objectives provides an interesting reference point for the theme of this paper. Bloom's original (1956) framework identifies six levels of learning represented as a pyramid: knowledge, comprehension, application, analysis, synthesis, and evaluation – with the implication that each level of the pyramid represents a higher order or learning. In this conception, however, 'knowledge' is only really a facet (i.e. 'knowing-that' and based upon knowledge of facts). With comprehension as the next level (being able to describe and explain) it is interesting to note that *description* and *explanation* are conceived at the same level. At all subsequent levels knowing-*why* is a prerequisite. In many ways, while Bloom's taxonomy could be revised to be more relevant to current circumstances it also represents a model that presents the fundamental components of integrated reflection.

5. Conclusions

This paper has been explicitly theoretical in pointing to opportunities for ICT innovation that could support integrated reflection. Theory and practice are mutually informing and co-evolve in multiple venues. The development of e-learning is no different and ever since the term was first coined in the late 1990s it has evolved as both a discourse and a practice. In conclusion, the following observation and question from Moor (2006) seems appropriate:

> There is a debate in the philosophy of science whether science *explains* nature or only *describes* it. Clearly, laws of nature are only descriptive. They describe by words or by mathematical equations the rules and order of nature. They give an answer to the question how things happen in nature, but they don't answer the question *why* things happen this way. This descriptive knowledge of nature is enough for any practical purpose, but curious creatures like us are not content with this kind of knowledge. We also want answers to the question *why*.
>
> The question "*why*" is about reason. Reason is not something that exists in nature, at least not in a way that we can perceive by our senses. Reason exists in our minds, in our thoughts. It is beyond the boundaries of our possible knowledge about nature. What tools do we have to deal with what lies beyond these boundaries? [20]

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