Distributed Cognition as an Instructional Framework ®

Carole Steketee, Jan Herrington and Ron Oliver

Edith Cowan University

Abstract

Numerous claims have been made that the computer, when used as an intellectual partner, has the potential to enhance learning (Salomon, 1993), and even transcend the boundaries of human information processing (Pea, 1985). This 'intellectual partnership' however, is an elusive concept, one that has rarely been documented and only superficially defined.

The notion of 'partnership' implies teamwork where the task of learning something is distributed between the student, the computer or any other tool that facilitates the learning process. When learning is distributed, cognition is not solely an individual pursuit, but rather is shared amongst resources found within the learning environment (Pea, 1993). A type of communal milieu is developed within which students, together with other students and resources, construct new knowledge and understandings.

While comprehensive discussions about distributed cognition have provided us with insights into the value of this phenomenon, few have addressed what it actually looks like as an instructional model. If this construct can facilitate effective use of computerised cognitive tools then the question remains, how do we do it?

The following paper attempts to address this question and reports the findings from the first stage of a PhD study that examined the fundamental characteristics of a *distributed learning environment*. These findings have emerged from the literature and from the subsequent implementation of a proposed framework within a tertiary learning context.

What is distributed cognition?

Imagine a student studying a chapter in a textbook. It is quite likely that this student will use a textliner to highlight important points and key ideas, make notes in the margin, and perhaps summarise the overall meaning in a separate notebook. Even though these notes may not be internalised within the student's head at the time of reading the chapter, they still represent his or her thinking and reasoning nonetheless. They are the observable characteristics of the student's cognition being distributed to resources in the instructional environment. And although the student may not remember these notes in detail once the textbook is closed, they will become a significant point of reference in preparation for exams at a later date.

This example encompasses the essence of distributed cognition, that is, thinking and learning does not occur within the mind of an individual alone, but is shared with and distributed across a variety of sources found within the learning environment (Pea, 1985, 1993; Perkins, 1993; Salomon, 1993). Opinions tend to differ however, in relation to intelligence and whether it resides in the minds of individuals or in the environment, and consequently, a variety of conceptions of distributed cognition exist.

These variations form a continuum (Moore & Rocklin, 1998). At one end, is the belief that an individual's cognition is a separate entity to cognition that occurs within a distributed learning environment. Proponents of this conception acknowledge that intelligence primarily resides within the minds of individuals, but is amplified significantly as a result of effective use of resources found within the learning environment (Perkins, 1993; Salomon, 1993; Derry, duRussel & O'Donell, 1998; King, 1998).

At the opposite end of the continuum is the belief that intelligence cannot be decontextualised from activity, nor from the resources used during this activity (Norman, 1993; Pea, 1993; Reusser, 1993; Hewitt & Scardamalia, 1998). While intelligence enables this activity, it is not purely the intelligence of an individual alone. Rather, intelligence is distributed across and between resources within an environment, such as other individuals, physical artefacts, symbols

- anything that contributes to the achievement of the goal for which the activity was carried out in the first place (Pea, 1993). Resources possess an intelligence of their own, and individuals exploit this intelligence when using them for particular purposes in learning activities. Therefore, it is impossible to separate individual cognition from the cognition embodied in the learning environment.

In between these two extremes is the belief that intelligence is an individual construct, however, more credence is given to the role of resources found within the learning context. Proponents of this conception believe that embedded in the design of an artefact (or symbolic system) is an intelligence that has been shaped by the artefact's originator (Lebeau, 1998). This embodied intelligence is subsequently distributed to those who use it as a tool in learning. However, this intelligence contributes to, but is still separate, from an individual's intelligence.

The Social Nature of Learning

The differences between these conceptions are important, but no more so than their similarities. While each of these views takes a particular position on individual cognition, they collectively acknowledge that learning is enhanced through interaction with, and active manipulation of the social and physical world. This contention is closely aligned with Vygotsky's assumption that mental functions are mediated by the use of tools as well as through collaboration with other individuals (1978). Learning, in this light, is a shared process - a procedure that occurs in a team-like fashion where the individual works with any number of environmental resources as partners in cognition (Salomon, 1993).

These environmental resources can be described as either the individual's own intellectual resources (eg, mental models, metacognitive knowledge), social resources (eg, the teacher, peers), symbolic resources (eg, content-specific language and symbols), and physical resources (eg, textbooks, computers). They are defined by the culture of the learning environment and, as such, are the means through which individuals who use them gain access to, and interpret that particular aspect of their world (Crook, 1996).

Just how the distribution process occurs is best explained using Salomon's spiral-like model of reciprocal relations between individual cognition and distributed cognition (1993). This model demonstrates the reciprocal and cumulative-like effects the individual and the distributed learning environment have on one another. For example, when an individual is presented with a learning task, he or she usually considers it in light of existing knowledge on the subject. This existing knowledge is then cultivated in conjunction with other individual and classroom resources. He or she might consult the teacher and peers, as well as available physical artefacts such as textbooks and encyclopedias. Content-specific language and symbols will probably be used, as will cognitive and metacognitive learning strategies. These resources facilitate the individual's thinking and learning on the subject, and contribute to his or her developing understanding. This revised understanding in turn determines the type of learning task presented in the future, and the cycle begins again. This process is represented diagrammatically in Figure 1.

Figure 1. The distribution of cognition in a classroom learning environment

Perkins (1992, 1993) warns educators however, not to assume students will automatically use resources simply because they are available. For students to seize opportunities offered by a resource, they must a) be sufficiently motivated to do so, b) be fully aware of its potential, and c) feel confident that it will live up to expectations (Perkins, 1985). These three factors cannot be guaranteed in most learning environments and, as such, if students are to be encouraged to distribute their cognition, a distributed learning environment needs to be engineered and implemented. The following section explores distributed cognition as an instructional model and discusses preliminary findings resulting from its implementation within a tertiary learning environment.

What does a distributed learning environment look like?

In an effort to uncover the fundamental characteristics associated with a distributed learning environment, the literature was extensively reviewed.

Three main characteristics emerged; *teaching context characteristics*, *student characteristics* and *student-process characteristics*. These characteristics are interrelated and together constitute a cognitive system. As with any system,

implementation of change in one area will induce change in another (Biggs & Moore, 1993). For example, as indicated in Figure 2 *teaching context characteristics*, together with *student characteristics* influence *student-process characteristics*, which ultimately effects learning outcomes.

Figure 2. Characteristics of a distributed learning environment

The *teaching context characteristics* comprise a wide range of complex phenomena. Not only do they incorporate factors such as curricula, teaching and assessment methods, academic tasks, rules and routines, they also encompass the overall mood of the classroom, which is also known as classroom climate (Biggs & Moore, 1993) or classroom ethos (Brown, Ash, Rutherford, Nakagawa, Gordon & Campione, 1993). Together, these factors convey messages to students about the type of learning that is desired and rewarded, which impacts upon *student characteristics*.

Student characteristics relate to students' perceptions of the learning environment and their roles within it. These perceptions influence the students' commitments to the learning methods, as well as their acceptance of the responsibility they have for their own learning and the learning of others. Consequently, these perceptions affect the way students approach their learning, that is, the processes they adopt.

Student-process characteristics refer to students' use of resources as they endeavour to learn something. Resources typically available within the classroom environment can be categorised as social, physical, symbolic and the individual's intellect. While it is possible for individuals to pursue learning tasks drawing on perhaps only one source (eg, their prior knowledge on a concept), this distributed learning framework argues that cognition is most powerful when it is distributed across a variety of sources. In fact, while these sources are operable on their own, their full potential is most likely to be achieved when used in conjunction with other sources.

The specific features of these characteristics, as they have emerged from the literature, are outlined in Table 1.

Table 1. Characteristics of a distributed learning environment

Characteristics	Features	Supporting Authors & Theorists
Teaching Context Characteristics	Teacher Features	
	Models distributed learning.	Pea & Gomez, 1992
	Designs learning experiences that challenge students to work within, and push beyond their zones of proximal development (ZPD).	Brown, et al., 1993
	Makes available a variety of resources that contain support mechanisms for a range of ZPD's	Brown et al., 1993; Pea & Gomez, 1992; Pea; 1993; Perkins, 1992
	Explicit instruction in how students can maximise the potential afforded by resources.	Pea, 1993
	Explicit instruction in cognitive and metacognitive	

	learning strategies. Explicit instruction in participation frameworks (eg, collaborative group work, jigsaw method etc). <u>Curriculum Features</u> Emphasis on depth of understanding rather than accrual of a wide knowledge base. <u>Task Features</u> Authentic activities that are representative of real world problems and situations. <u>Assessment Features</u> Emphasis on social as well as individual construction of knowledge and understandings, rather than memorisation of information.	Pea, 1985 Brown et al., 1993 Brown et al., 1993 Pea & Gomez, 1992; Pea, 1993 Brown et al., 1993
Student Characteristics	Co-learners, co-teachers and co-researchers who are committed to communal learning. A sense of individual, as well as joint, responsibility for the achievement of learning goals. A high regard and respect for other members of the learning community and its resources. Acknowledgment that existing knowledge belonging to an individual (and others, contributes significantly to the learning of new concepts. Willingness to share this knowledge and open acceptance of others' perspectives.	Brown et al., 1993 Brown et al., 1993 Salomon, 1993; Hatch & Gardner, 1993; Nickerson, 1993
Student-process Characteristics	Collaboration between peers, teachers and others within and beyond the classroom environment in the development of understandings. Use of language, symbols, diagrams and pictures that are representative of the subject matter as a	Pea & Gomez, 1992; Pea, 1993; Perkins, 1992; Hatch & Gardner, 1993; Perkins, 1993; Rogers & Ellis, 1994 Pea & Gomez, 1992; Pea, 1993, Perkins 1992; Perkins, 1993.

	catalyst to clarify and explain the meaning of concepts as well as the relationships between concepts. Communicate, collaborate and think through a variety of physical artefacts found within and beyond the classroom environment. Deployment of cognitive and metacognitive strategies that facilitate the development of social and individual understandings. Executive function is shared between the student and the environment, but ultimately control lies with the student.	Brown et al., 1993; Pea & Gomez, 1992; Pea, 1993, Perkins 1992; Hatch & Gardner, 1993; Perkins, 1993; Rogers & Ellis, 1994 Cole & Engestrom, 1993; Pea, 1993; Perkins, 1992; Perkins, 1993.

Discussion

Figure 1 describes, in theory, how distributed cognition works. As the above framework indicates however, many factors contribute to this process. By virtue of its principle position within the framework (see Figure 2), it can be inferred that *teaching context characteristics* are paramount within a distributed learning environment. The fundamental nature of the variables, which prevail within this component, will directly and indirectly impact upon the course of events within the other components.

For example, the social, physical, symbolic and intellectual resources shown in Figure 1 are essentially support mechanisms that enable students to navigate their way through their zones of proximal development (Vygotsky, 1978). A ZPD is the phase within which an individual can grasp a concept given appropriate help and support (Brown et al., 1993). These supports are evident in the links, ideas, clues and prompts that encourage students to negotiate meanings of concepts and develop understandings. Mastery of these concepts pushes back the boundaries of the individual's ZPD (Brown, et al., 1993) so while supports are no longer required for learned concepts, new supports are needed for subsequent, more complex concepts.

Teachers, therefore, need to provide resources that contain appropriate supports for a range of ZPD's (Brown et al., 1993; Pea & Gomez, 1992; Pea; 1993; Perkins, 1992). They will also need to instruct their students as to why these supports are necessary, when to use them, when not to use them and how to maximise their affordances (Pea, 1993). While this instruction is initially explicit, repeatedly reinforced and practised, distribution of cognition over a range of resources will eventually become part of the classroom learning culture.

Fundamental to this training is an emphasis on resources as intellectual partners, as instruments of cognition that are essential to effective learning. Tasks and assessment procedures, therefore must be designed around the interrelationships that prevail between students, teachers, tools and symbols (Brown et al., 1993). While resources exist in most classrooms, they are often not perceived to be integral to effective cognitive functioning, and the potential power they yield often goes unnoticed (Perkins, 1992). This is evident in activities that encourage students to work without supports and assessment methods that reward solo performances (Resnick, 1987; Perkins, 1992).

While some teaching context characteristics are fixed institutional features (eg, curriculum content), most of them are teacher-controllable and a direct reflection of his or her commitment towards distributed learning. The teacher is in a position of power to lay the foundations for a distributed learning environment, and unless these fundamentals exist, any form of distributed cognition that occurs will be superficial in nature. The teacher is the group-leader who distributes his or her expertise around the classroom, and through modelling and coaching, trains the students to do the

same (Pea & Gomez, 1992). He or she assumes control initially, but gradually cedes executive function to the students as they become competent, independent learners (Perkins, 1992).

That is not to say, however, that students have no input into the success of a distributed learning environment. While an appropriate teaching context is paramount, it must be coupled with appropriate *student characteristics*. Learning within a distributed learning environment, while rewarding, is not easy and demands much mental effort and involvement on the part of the students. They must be committed to the development of a learning environment that thrives on discourse, collaboration and consultation with a variety of resources. Individuals are responsible for their own learning, and to a great extent, the learning of others too.

These features were clearly evident when the above framework was implemented into a fourth year unit within the Bachelor of Education course at Edith Cowan University. In an effort to determine the degree to which students distributed their cognition to individual, social, physical and symbolic resources, the *teaching context characteristics* outlined in Table 1 were adhered to, and students were trained throughout the semester to exploit the intellectual partnerships evident in the learning environment.

A preliminary analysis of data gleaned from this implementation has shown that the high level of commitment required of students, especially those whose learning style favours traditional teaching methods, is a big ask. While it is not impossible to encourage these students to distribute their cognition, years of habit are difficult to ignore. Furthermore, commitment is often influenced by study intentions, particularly for tertiary students who come to university for a variety of reasons. Those who are genuinely interested in the content are more likely to distribute their cognition compared to those whose main aim is to graduate with minimum effort. Whether or not *all* students need to be committed for the above framework to be successful is a question that still remains open. A more comprehensive analysis of the data will hopefully reveal the answer to this question, and others.

Conclusion

The idea that learning is facilitated by cognitive resources is not new, revolutionary nor even debatable (Nickerson, 1993). For centuries, people have made use of tools to enhance physical and cognitive abilities (Cole & Engestrom, 1993). For whatever reasons, however, distribution of cognition within the classroom environment is not such a natural phenomenon and, as such, a distributed learning environment needs to be engineered. A complex combination of appropriate *teaching context characteristics* and *student characteristics* need to be in place to allow the necessary *student-process characteristics* to transpire. If any one feature within the system is not conducive to the distribution of cognition, then the framework is unlikely to succeed. The literature reveals however, that success is worth striving for as the intellectual partnership created by distributed cognition can yield powerful learning rewards.

Having developed a distributed learning framework and explored its nuances, the next stage of this study will be to use it as a catalyst for the effective use of computerised cognitive tools. It is anticipated that this environment will afford students powerful opportunities to think and learn in ways that, as Pea claims, transcend the boundaries of human information processing (1985).

References

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