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Author(s)	David Hung and Philip Wong
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Toward an Information and Instructional Technology Research Framework for Learning and Instruction

David W. L. Hung
Philip S. K. Wong

The time is ripe for information and instructional technologies (IIT) to make major contributions toward improving learning in education. The increasing understanding of learning environments, intelligent systems, agent technologies, and other related educational platforms enables us to now have a better perspective of how technology should be used in the context of pedagogical and organizational design (Brown & Duguid, 2000). As processes and work become increasingly complex, technology can assume the more mundane functions and free us for tasks that are more complex and fuzzy. Additionally, as society becomes more global, collaboration across borders through networks becomes increasingly necessary. More interaction and collaboration efforts are needed with other institutions, organizations, and societies.

In order for Singapore to make an impact on developments in learning and instruction, we felt that it was necessary to identify the strategic areas for research that would make a contribution to knowledge and scientific advancements.

The IIT research framework, as described below, serves instructional and learning goals. We hope that these research directions will synthesize the latest global thrusts in educational technology and that the readers of this article benefit from such a synthesis.

David W. L. Hung and **Philip S. K. Wong** are with the Instructional Science Academic Group, National Institute of Education, Nanyang Technological University, Singapore (e-mail: wldhung@nie.edu.sg).

The *Instructional Science Academic Group* shares common educational perspectives that emphasize the importance of carefully designed activities involving students in appropriating skills and concepts through active, constructive, and situated engagement with knowledge (Brown, Collins, & Duguid, 1989). Technology can support the above processes, complemented with teachers' and students' guided inquiry or facilitation, challenges, reflection, and communication. Technology can also present challenging scenarios (Cognition and Technology Group at Vanderbilt, 1996), provide simulations, present complex data through visualization tools (Gordin & Pea, 1995), and assist in assessment (Pea *et al.*, 1999), knowledge building (Scardamalia & Bereiter, 1996), community building (Brown & Campione, 1996), and others.

A Dozen Research Areas

Considering the emerging technologies from the educational, instructional, and learning perspectives, we can identify 12 fruitful areas of IIT in education research:

1. ***Pedagogy ot online environments.*** There is a current need to formulate standards and benchmarks for online learning. Learning in online environments has received such hype that the business world is dictating the parameters for what e-learning should be. There is a need to consider what content dimensions should be online, learning styles of students, and facilitating dispositions of teachers. There is an important need for education to spearhead the pedagogical directions for e-learning. A significant notion is how technology or tools can "distribute cognition" with the learner and instructor.

2. ***Simulation, visualization, and modeling.*** With modern technology and complex algorithms, we now have the ability to synthesize and collate complex data and variables into "views" that are more easily handled cognitively. Students can benefit from simulations in order to understand and play with variables that would otherwise be perhaps costly and dangerous. Simulations and visualizations should generally be content-specific, e.g., in the sciences.

3. ***Mind-tools or cognitive tools.*** There is currently an important emphasis on how epistemic tools can help students to structure knowledge. These structures can be incorporated into IIT-based environments. These epistemic structures could include lists, tables, concept-maps, tree-structures, etc. Technology could also facilitate the collaborative construction of knowledge using these structures.

4. ***Assessment tools.*** Technology can track students' progress *in situ*, and such tools and models can assist teachers in understanding students' conceptual difficulties in tasks such as project work. These tools generally provide teachers and students with meta-knowledge of their work in progress. Teachers can be

helped, for example, if "data" of students' activities, such as online chats, can be synthesized into graphs showing their involvement and progress.

5. ***Wireless computing.*** The widespread advancement of wireless technology, e.g., the cell phone, is making headway into learning and educational domains. How can technologies such as EduPad (a portable book-like wireless device in which information is stored in chips, developed in Singapore) be effectively integrated into learning and instruction? How would wireless technology transform the schooling processes now dominant in the form of traditional classrooms?

6. ***Tools for learning communities.*** Recent research literature has emphasized the social nature of learning, stressing the processes and social structures undergirding knowledge construction. Such a focus has resulted in a proliferation of networked environments, multi-user virtual collaborative environments, and agents that support collaborative work. We are increasingly recognizing that the social practices that revolve around schooling are as important as the learning that occurs within the individual mind. A lot of implicit learning or incidental learning occurs as students and teachers interact in a social context. How can social contexts be appropriated into virtual environments? There is a need for facilitating tools to assist teachers in scaffolding social discourse and constructing tools that aid students in building knowledge.

7. ***Tools for project work and authentic tasks.*** We increasingly recognize that tasks given for learning must be authentic and challenging. What kinds of tools support such a learning process? How do we design for authenticity? Issues of authenticity relate to how learning should be context-rich, where associations of meanings are made personal to students' perceptions. Additionally, it is necessary for learning to be designed for transfer and generalizations to other contextual and disciplinary domains.

8. ***Integration of media, tools, and strategies.*** With the proliferation of different multimedia applications and tools, there is a need to develop sound pedagogical strategies for how these types of media would be appropriately used in learning and instruction.

9. ***Qualitative changes in learning.*** Complementary with the use of tools, strategies, and media, there is a need to measure the qualitative changes, e.g., conceptual and epistemological, in students' learning. Such a focus is at the forefront in current research. In addition, the need to design for transfer of learning or generalization of meanings is related to this aspect of qualitative change.

10. ***Multiple intelligences and learning styles.*** Research must address the dimension of relating multiple intelligences to learning and teaching styles with the appropriate use of media, tools, and strategies.

11. ***Knowledge states and types.*** Depending on the kinds of knowledge that students acquire, different tools, strategies, and media should be used for learning and instruction. We fundamentally believe that not all knowledge needs to be constructed, e.g., basic multiplication tables or the periodic table of elements. It is through the appropriation of such cultural-scientific artifacts that students can subsequently negotiate and construct further understanding.

12. ***Social-cultural issues related to IIT-enriched environments.*** Although social-cultural (and historical) issues are not new (for example, Vygotskian and other Marxist-related theories), little is known of the implications for IIT-enriched environments. Contexts such as policies and societal norms have a profound impact on learning outcomes. Other contextual and policy issues include the important notion of infrastructure and management support.

Conclusion

Although there may be other research themes related to IIT, we believe that the 12 directions noted above will place Singapore at the forefront of research internationally. We hope that this article will also serve as a platform for collaboration with researchers and educators throughout the world. To date, we have several government-funded research projects (ranging from US $50,000 to US $250,000) but many other research opportunities are available. □

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