

Beyond cognitive and metacognitive tools: the use of the Internet as an 'epistemological' tool for instruction

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Abstract

This paper argues that Internet-based instruction should not be only perceived as a cognitive tool or a metacognitive tool; rather, it can be perceived and used as an epistemological tool. When the Internet is used as an epistemological tool for instruction, learners are encouraged to evaluate the merits of information and knowledge acquired from Internet-based environments, and to explore the nature of learning and knowledge construction. This paper further asserts that Internet-based instruction is perceived as a way to help learners develop advanced epistemologies. On the other hand, developmentally advanced epistemological beliefs can facilitate the practice of Internet-based instruction.

The use of computers or the Internet as cognitive or metacognitive tools

The study of cognition explores how an individual acquires information and knowledge. Educational psychologists also propose the idea of metacognition, which describes an individual's capacity to reflect upon his or her actions and thoughts. Hence, metacognition involves a self-regulatory skill whereby the learner monitors his or her own learning processes and knowledge construction (Tsai, 2001a). In the past few years, the computer or the Internet has been widely used as a cognitive and/or metacognitive tool to facilitate students' learning (Jonassen, 1996, 2000). In this perspective, the major purposes of computer or Internet-based instruction are to help learners acquire knowledge and relevant skills, learning how to reorganize knowledge and learning how to learn. (As this paper presents a general discussion about how the Internet can be

Table 1: The use of computers or the Internet as cognitive or metacognitive tools

	<i>Purposes</i>	<i>Possible methods</i>
Cognitive tool	<ul style="list-style-type: none"> • Information acquisition • Knowledge acquisition and comprehension • Knowledge construction or co-construction • Developing reasoning and problem solving skills 	<ul style="list-style-type: none"> • Information search • Visualisation or virtual reality • Test bank • Synchronous and asynchronous conferencing
Metacognitive tool	<ul style="list-style-type: none"> • Select and filter information • Reorganise knowledge • Conceptual change • Making connections with previous and other knowledge and experiences • Learning how to learn and how to apply knowledge 	<ul style="list-style-type: none"> • Semantic networks (or concept maps) • System modelling • Hypermedia or database construction • Providing learning profiles of web navigation for learners' review

used as an epistemological tool, learners are referred to as students who may use the Internet for instructional purposes. In the current stage, this group of learners often includes those in higher education and high schools.) Table 1 shows a detailed description of the purposes and their possible methods. For instance, as a cognitive tool, students can navigate an Internet-based virtual reality system to understand the functions of the human body (eg, Chou, Tsai & Tsai, 2001) and then acquire the relevant knowledge. Or, some three-dimensional virtual environments are helpful to describe physical and chemical processes, facilitating better conceptual understanding in science (eg, Trindade, Fiolhase & Almeida, 2002). As a metacognitive tool, some computer- or Internet-based systems have been developed to help students construct their concept maps (eg, Reader & Hammond, 1994; Tsai, Lin & Yuan, 2001). Through these systems, students can reorganise their knowledge and make meaningful connections with other knowledge and experiences. In addition, students' metacognition will be enhanced if they can monitor and review their learning paths. Internet-based environments, obviously, have the additional capacity to record every student's navigation and learning paths in the courseware. This record within the learning environments can, at some points, allow students to review the pathways navigated and to evaluate what they have done in the course of exploring ideas. The study conducted by Salmon (2002) shares a similar pedagogy. Through revealing navigation records, the participants' learning in Salmon's study has been enhanced when they are given opportunities for reflecting on their on-line learning with the support of a trained e-moderator.

The use of the Internet as an epistemological tool

Epistemology is the study of knowledge and knowing, and it explores the questions such as 'what counts as knowledge?' and 'what does it mean to know and to believe?' Therefore, epistemology deals with the nature of knowledge and beliefs. Educators have also

concluded that learners' (across different ages) epistemologies may affect their learning strategies, reasoning modes and decisions when encountering new information (Hofer, 2001; Hofer & Pintrich, 1997; Sinatra, 2001). Due to the rich information in Internet-based resources and decontextualised nature of Internet-based interactions, this paper asserts that the use of the Internet should not be limited in cognitive or metacognitive tools; rather, it can be perceived as an epistemological tool. For example, the diverse perspectives within Internet-based environments provide opportunities for learners to develop evaluative standards to judge the merits of information and knowledge, thus exploring some epistemological issues. At the same time, learners may shape or reshape some explanatory models or commitments to conceptualise new experiences. These models and commitments can be applied to decision making in everyday contexts or the learning of different disciplines. Also, through interactions with a variety of information, peers, and even experts in Internet-based environments, students can acquire more opportunities to elaborate many theoretical facets within a knowledge domain. And, if the interactions are appropriately processed, students may gain a more proper understanding about the nature of knowledge and technology, such as that the value of knowledge and technology is relative to the contexts in use, thus possibly reshaping their worldviews. All of these views, beliefs and understanding, clearly, are related to learners' epistemologies.

Table 2 shows how the Internet can be perceived as an epistemological tool. The purposes listed in Tables 1 and 2 imply a hierarchy, an ascending priority from more fundamental or lower-order purposes to more integrated or higher-order purposes. To repeat, epistemology is the study of knowledge and knowing.

Therefore, when the Internet is perceived as an epistemological tool, learners are encouraged to explore:

- Which information is more important than other information?
- Which information or knowledge items are more reliable and valid than others?

Table 2: The use of the Internet as an epistemological tool

	<i>Purposes</i>	<i>Possible methods</i>
Epistemological tool	<ul style="list-style-type: none"> • Commitments or judgmental standards to information and knowledge • Developing ideal or explanatory models • A proper understanding about the nature of technology, learning and teaching • Promoting integrated or interdisciplinary epistemological commitments • Shaping philosophy and worldviews 	<ul style="list-style-type: none"> • Reflective judgements in web navigation • Decision making in web contexts • Meaningful interactions with web materials and peers or experts

Epistemological

Metacognitive

Cognitive

Figure 1: Three layers of using Internet for instruction

- What counts for 'knowledge'?
- What is the nature of their knowledge (and learning)?
- How to resolve the conflicts between various perspectives of knowledge?
- How to effectively integrate all sorts of knowledge into a coherent or viable framework?

As a result, the use of Internet-based instruction as an epistemological tool may broaden its purposes, and help learners develop some commitments to, or models of, a variety of knowledge fields and contexts. The following two sections will show two theoretical examples of the interplay between Internet-based instruction and epistemological beliefs.

One may argue that the definitions and distinctions between cognition, metacognition and epistemology may be overlapped and open to complex debate. To reveal the similarities and differences among these three, this paper suggests a simple three-layer hierarchy for the purposes of Internet-based instruction, from 'cognitive,' 'metacognitive' to the highest 'epistemological', shown in Figure 1. It is asserted that the use of the Internet as cognitive and metacognitive tools is a foundation for implementing the Internet as an epistemological tool. In other words, the use of the Internet as cognitive and metacognitive tools is a necessary, though not sufficient, condition to use it as an epistemological tool. For instance, if students do not have to acquire knowledge or do not have metacognitive ability to monitor their learning processes through Internet-based instruction, they will not be aware of the nature of their learning and the nature of knowledge construction, nor achieve the epistemological goals presented above. Therefore, if the Internet is used as an epistemological tool, using it as a cognitive and metacognitive tool is a prerequisite. On the other hand, some students may simply acquire knowledge from Internet learning environments (cognitive), without explicitly reflecting their ideas (metacognitive) nor involving epistemological reflections (epistemological).

Theoretical example 1: the use of the Internet to develop epistemological commitments in science education

Tsai (2001a) has discussed how to possibly use the Internet to develop appropriate epistemological commitments in the field of science education. Epistemological commit-

ments are evaluative standards utilised to judge the merits of knowledge such as its generalisability, usefulness and internal consistency (Posner, Strike, Hewson and Gertzog, 1982). Tsai, for example, believes that it is a promising approach to provide opportunities for students (perhaps those in higher education or gifted high school students) to interact with professional scientists and elaborate shared understandings of the belief systems and ways of developing scientific knowledge and theories. Students can serve as apprentices to scientists by evaluating evidence collected by scientists during scientific experiments, to discuss the significance of experimental results and to elaborate the complicated interplay among theories, evidence and observations. Internet technology makes it possible for students to have connections with scientists and to join scientific research regardless of the constraints of time and location. The dialogue and interaction between scientists and students can help students shape more appropriate epistemologies toward scientific knowledge. For instance, Post-Zwicker *et al* (1999) have provided Internet-based learning environments where high school students could conduct experiments in plasma physics and fusion energy with professional scientists and then obtain real-time data analyses and interpretations. Through the Internet, students can participate or observe the data collection and interpretations by scientists, thus gaining a better understanding about the processes of developing scientific knowledge. Furthermore, the interactive discussion for the questions such as 'what counts as valid and reliable observations?' and 'How to frame valid findings and knowledge' between students and scientists may assist students in questioning a dualistic (absolutely right or wrong) position about the status of scientific knowledge.

Moreover, students may not need to interact with scientists easily to find scientific reports on the Internet and make interpretations, critical judgements about the evidence, and explore relationships to other such scientific papers scientists have posted on the Internet. Many of these reports, as well as interesting methods and anecdotal summaries are currently online. Students can re-evaluate these reports by either gathering more data or contrasting a series of relevant studies. If necessary, the students can also respond back to the e-mail address and see whether the scientists will discuss the information the students have extracted. Or, to be more realistic, there are many online forums with a specialised knowledge focus or clear research interest; students may post some related questions for clarification, and it is expected that some experts will respond to these questions (however, students need to carefully verify the information provided). With the assistance of Internet technology, students, through reading these reports and interacting with professional scientists or other experts, may develop shared understandings and appropriate epistemological commitments about the ways of thought that characterise scientific inquiry. These Internet-based activities also assist students in examining their assumptions about knowledge and how it is acquired, thus fostering epistemological development. (The idea of the epistemological development is originated from Perry's work (1970). Perry (1970) has proposed the following stages of epistemological development: dualism, multiplicity, relativism, and commitment within relativism.)

Theoretical example 2: information commitments expressed by experts and student web users

Educators often view a learner's experiences, knowledge and information as a 'conceptual ecology' in his or her brain. The 'epistemological commitment' is one of the major features in an individual's conceptual ecology (Posner *et al*, 1982). To repeat, epistemological commitments involve judgmental standards used to evaluate the merits of knowledge such as its generalisability, usefulness and internal consistency. Students with various backgrounds may have quite different epistemological commitments toward the same domain of knowledge. Similar to the ideas of epistemological commitments, Tsai (2004) has proposed information commitments as a set of evaluative standards which web users utilise to examine the usefulness and (relative) accuracy of Internet-based materials.

Before presenting a small case study about people's information commitments, it may be necessary to clarify terms used in this paper, that is, epistemologies, epistemological commitments and information commitments. Figure 2 shows the relationships among them. Epistemologies deal with learners' general beliefs about the nature of knowledge and knowing, while the epistemological and information commitments focus on the standards and beliefs for evaluating the merits of knowledge and information. Certainly, the epistemologies will guide epistemological and information commitments and cover a wider range of views and beliefs. In addition, knowledge may be derived from a variety of information sources; in this perspective, epistemological commitments involve a larger scope of conceptions than information commitments, as shown in Figure 2.

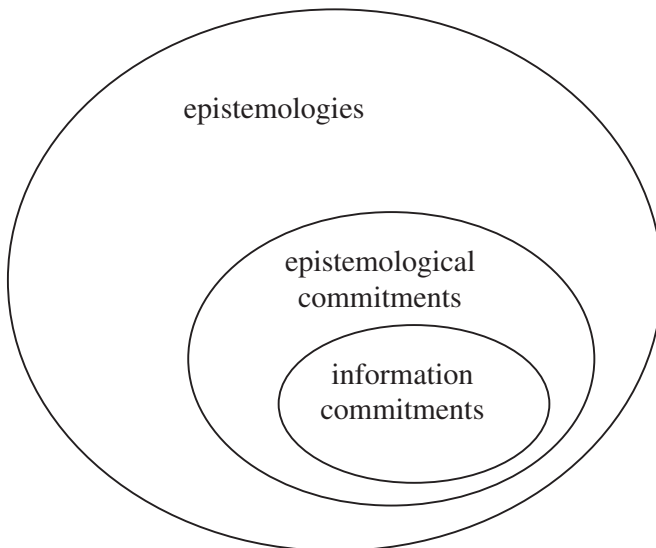


Figure 2: The relationships among epistemologies, epistemological commitments, and information commitments

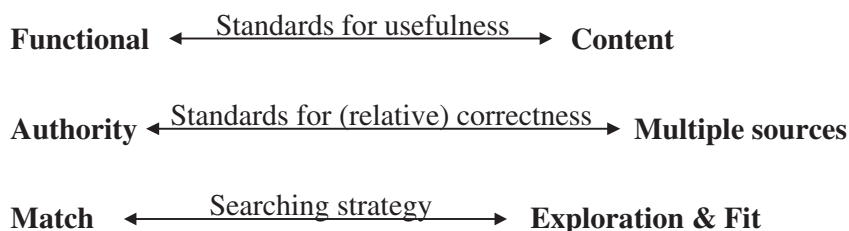


Figure 3: A framework categorising information commitments

To explore people's information commitments, Tsai (2004) interviewed two experts (university professors) specialising in Internet-based instruction and ten college students, and then proposed a framework categorising the information commitments, shown in Figure 3. The framework described a range of commitments from 'functional' (such as the ease of retrieving or searching information) to 'content' (the relevancy to the intended search) as the evaluative standards about the usefulness of Internet-based materials. A range of views from 'authority' (the authority or the significance of the web site per se) to 'multiple sources' (such as the information from other web sites, prior knowledge, peers or other printed materials) were also found for the judgmental standards about the (relative) correctness of Internet-based materials. The framework also reflected an information searching strategy ranged from 'match' (by keywords or the degree of exact mapping) to 'exploration and fit' (by metacognitive and purposeful thinking).

The experts in the study expressed information commitments more oriented to 'content', 'multiple sources' and 'exploration and fit', while many of the college students held commitments more aligned with 'functional', 'authority' and they utilised a 'match' searching strategy in Internet-based environments. In light of these experts' responses and educational studies about Internet-based learning (eg, Hess, 1999; Marchionini, 1995; Tsai & Tsai, 2003), information commitments more oriented to 'content', 'multiple sources' and 'exploration and fit' will help become effective and efficient web users. The findings above also indicated that people with different experiences and backgrounds of using the Internet had different information commitments to examine Internet information. The professional expertise and rich experiences may help the experts (specialised in Internet-based instruction) hold 'content', 'multiple sources' and 'exploration and fit' information commitments.

Tsai (2004) has also suggested that these information commitments may also be shaped by people's epistemologies. Educational research has revealed that students' epistemologies or epistemological beliefs may influence their learning approaches and thus learning outcomes (Hofer, 2001; Hofer & Pintrich, 1997; Tsai, 1998, 2000a). Similarly, students' information commitments may affect their web-learning behaviours and outcomes. As a result, educators and teachers need to help students attain proper information commitments (such as those of 'content', 'multiple sources' and

'exploration and fit' described previously) when navigating Internet-based learning environments. It follows that they are expected to learn effectively and efficiently in the environments.

Assertions of the use of Internet as an epistemological tool

Assertion 1: Learners with different epistemological beliefs benefit differently from Internet-based instruction

Although the topic of individual differences gains growing interest among educational researchers, how students with different epistemological beliefs will perform in computer or Internet-based learning environments has not been carefully investigated. One of a few cases in the research literature may be the study completed by Windschitl and Andre (1998). Windschitl and Andre examined the merits of computer simulations (as an inquiry and open-ended instructional treatment) and the role of student epistemological beliefs on the efficacy of this instructional strategy. Their study showed a finding that students with more advanced epistemological beliefs (such as relativism or constructivist-oriented epistemologies) learned more with an exploratory computer-based instructional treatment, while students with less developmentally advanced beliefs achieved better in confirmatory and traditional-oriented instruction. Since Internet-based learning environments are open-ended in nature, and they allow for more flexibility, interaction and alternatives as well as provide more facets toward a knowledge domain, it is hypothesised that students with more advanced epistemologies (such as relativism) may benefit more from such environments (if used appropriately). However, the open-endedness and flexibility of the Internet learning environments may cause some inherent problems and complexities required to be acknowledged. For example, students may experience the disorientations of navigation or the inadequate ability in evaluating information. Therefore, the notions of 'information commitments' proposed earlier may be important to address these problems. Nevertheless, this paper believes that the Internet-based environments, if used with proper guidance, can help students obtain more facets about a knowledge domain, thus accommodating the needs of students with more advanced epistemologies (such as relativism or commitment within relativism). On the other hand, students with less advanced epistemologies such as dualism may learn better through traditional authority-type teaching where high certainty of knowledge is often highlighted. A situation like this can be illustrated in Figure 4—a hypothetical illustration for the relationships among epistemological positions, instructional methods, and learning outcomes, is basically inferred from the research work completed by Windschitl and Andre (1998). The studies by Tsai (2000a) and Linn and Eylon (2000) also show evidence related to this that students with advanced epistemological views learn better in reflective inquiry-oriented instruction. One important feature of the Internet-based instruction is to provide opportunities for inquiry learning and reflective thinking (Chuang & Tsai, in press). Clearly, more empirical evidence is required to support the hypothetical illustration shown in Figure 4, and a research project in Taiwan is currently undertaken to explore this. The axis of 'epistemology' indicates the variations of epistemological positions, ranging from dualism, multiplicity, relativism, to commitment within relativism (from left to right).

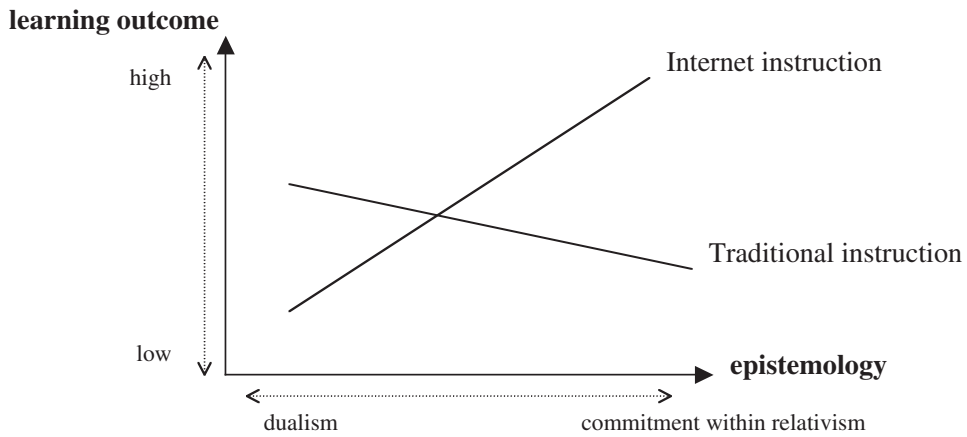


Figure 4: The interaction between epistemologies and different ways of instruction

If this hypothesis is true, possessing advanced epistemologies may be an important prerequisite for implementing Internet-based instruction.

Assertion 2: The use of Internet-based instruction will change or reshape learners' epistemologies

In recent years, educators have tried to change learners' epistemologies into more advanced relativist-oriented views, as these views are positively related to students' meaningful learning and better cognitive-processing strategies (Hofer & Pintrich, 1997; Tsai, 1998, 1999a). Some educators also claim that part of the goal of education is to promote epistemological development (Hofer, 2001; Perry, 1970). Students in this line of research are often asked to engage in the discussion of controversial issues, work on open-ended projects, discuss and analyse ill-structured problems, conduct cooperative learning or so-called constructivist-based instructional activities (King & Kitchener, 1994; Smith *et al.*, 2000; Tsai, 1999b). In particular, the subjects in Smith *et al.*'s (2000) study are sixth graders, suggesting that elementary school children are more ready to formulate sophisticated constructivist or relativist philosophical views about knowledge than many have thought. Internet-based learning environments contain rich information and a variety of perspectives and viewpoints for open-ended exploration or the debates of controversial issues. They also allow many ways of cooperative learning, such as synchronous and asynchronous. All of these features concur with the ways of fostering students' epistemological development by previous studies cited above. Therefore, it is hypothesised that Internet-based instruction may also facilitate the epistemological development, from dualism to commitment within relativism, as categorised by Perry (1970). This hypothesis is consistent with the two theoretical examples presented previously. The second example suggests that people with different backgrounds of using the Internet have different sets of commitments in judging the merits of web information, and expert users are likely to have more sophisticated commitments. The first example clearly describes how Internet technology may facilitate students' epistemo-

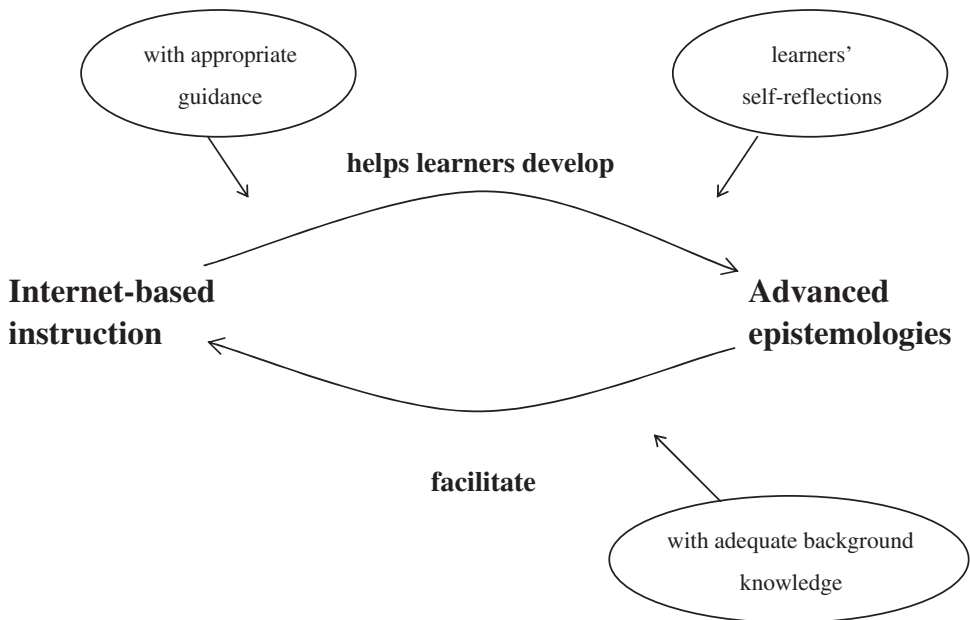


Figure 5: *The interplay between Internet-based instruction and epistemologies*

logical development in science education. Therefore, Internet-based instruction is perceived as one potential way to help students attain advanced epistemologies toward knowledge and learning.

In sum, the assertions above show an active interplay between Internet-based instruction and learners' epistemologies, shown in Figure 5. That is, Internet-based instruction, with appropriate guidance and learners' self-reflection, is perceived as a (but not *the*) way to help develop advanced epistemologies. On the other hand, developmentally advanced epistemological beliefs, with adequate background knowledge, can facilitate the practice of Internet-based instruction in the knowledge domain. Clearly, more empirical evidence should be gathered in the future to examine such a cyclical relationship between Internet instruction and the development of sophisticated epistemologies.

Concluding remarks

The use of computers or the Internet as cognitive and metacognitive tools concurs with the constructivist theories (Akhras & Self, 2002; Tsai, 2001b). Constructivist theories assert that knowledge is actively constructed by individuals, and that social interactions with others also play an important role in the construction process. Therefore, constructivists emphasise that instruction needs to carefully consider learners' prior knowledge and to encourage student-to-student as well as student-to-teacher interactions (Fosnot, 1996; Tsai, 2000b). For example, Internet-based instruction can contain

a test bank to assess each student's prior knowledge, and can then offer the appropriate guidance or instruction for the individual. Clearly, e-mail or Internet-based communications may also facilitate more student-to-student and student-to-teacher interactions.

The idea of the epistemological tool too, is consistent with the practice of constructivism, as constructivism does not merely involve learning theories; rather, it is a philosophical foundation guiding teaching practice and individual knowledge growth (Bodner, 1986; Staver, 1998). The use of the Internet as an epistemological tool also reveals a broader vision about learning, teaching and Internet-based instruction. Educators are encouraged to use or perceive the Internet as an epistemological tool when implementing instruction.

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