THE IDEAL ONLINE LEARNING ENVIRONMENT FOR SUPPORTING EPISTEMIC DEVELOPMENT
Putting the Puzzle Together

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This paper examines the concept of the ideal online learning environment of the future that would encourage the participating learner's epistemological development. Epistemological development refers to one's beliefs about the meaning of epistemological constructs, such as knowledge and truth and how those beliefs change over time (Hofer & Pintrich, 1997). Such beliefs begin as simplistic dualistic understandings of the world and knowledge as either right or wrong and develop to more complex understandings where one sees knowledge as being defined and shaped by the context in which it must be applied. This paper posits that advanced epistemological development is a desirable outcome for online education, explores the current limitations of online learning environments in terms of epistemic development, describes several emerging technologies in online education that can encourage epistemic development and, finally, discusses the overall implications for creating online learning environments that support epistemological development.

INTRODUCTION

This issue of the *Quarterly Review of Distance Education* is devoted to the future of distance learning. From this educator's point of view, distance education, as with every other form of education, should strive to create maximally effective learning environments for its participants. It is with the definition of "maximally effective" that various authors, researchers and scholars may begin to express divergent opinions and views. Although there are many potential components of "maximally effective" (e.g. cost effectiveness, effectiveness in attaining the desired learning outcomes, convenience), in this paper I will focus on one aspect of effectiveness: that of encouraging epistemological development.

Epistemological, or intellectual, development refers to one's beliefs about the meaning

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of constructs such as knowledge and truth and how those beliefs change over time (Hofer & Pintrich, 1997). In general, such beliefs begin as simplistic dualistic understandings of the world and knowledge as either right or wrong and develop into more complex understandings where one sees knowledge as being defined and shaped by the context in which it must be applied. Throughout this paper the basic premise will be that advanced epistemological development is a desirable outcome of any form of education. Specifically, individuals with advanced epistemological beliefs are more likely to be able to think through a complex, ill-structured problem, in context, and make a reasonable argument for the best of many solutions: a skill that embodies what is needed in many workforce positions today. As such, my vision of what distance education environments or online learning environments should be in the future must concern itself with how these environments support epistemic growth.

To develop this argument, I will:

- Briefly describe central concepts of epistemic development including an explanation of one particular theory, the Perry Model of Intellectual Development, and make an argument for the centrality of considering epistemic development for current and future online learning environments
- Examine at an overview level the research on the impact of curricular interventions on epistemic development, and the reverse; that is, how learners' current levels of epistemic development impact curricular interventions
- Examine the current state of online learning environments for their potential impact on epistemic development
- Within the framework of current emerging technologies, describe online learning tools that can positively impact epistemic development
- Summarize the implications of these innovations on the future of online learning environments

EPISTEMIC BELIEFS AND DEVELOPMENT

Also known as intellectual maturity, epistemic beliefs, and intellectual development, epistemological development describes one's beliefs about the meaning of epistemological constructs, such as knowledge and truth and how those beliefs change over time (Hofer & Pintrich, 1997). Although the theories differ in detail and scope, they suggest overall a common pattern of development that progresses from simple, black-white thinking, through an exploration of multiple perspectives, to complex, relativistic thinking. The developmental aspect contrasts this line of research from that on epistemic beliefs that seeks to identify categories of beliefs, such as externally controlled learning, simple knowledge, quick learning, and certain knowledge (Schommer, Crouse, & Rhodes, 1992).

There are several different stage theories for describing learners' levels of epistemological development, including epistemological reflection (Baxter & Magolda, 1992), reflective judgment (King & Kitchner, 1994), and Perry's levels of intellectual development (Perry, 1970, 1998). We briefly describe Perry's work and refer the reader to Hofer and Pintrich (1997) for a review of epistemological development theories.

Perry's scheme of intellectual development, conceived by William Perry (1970) during the late 1950s based upon interviews with approximately one hundred Harvard and Radcliffe students, describes nine stages (positions) through which students move during their intellectual development (see Table 1). Several Perry positions are relevant to college student development.

Position two reasoning, called multiplicity pre-legitimate, exhibits a view of the world that is bifurcated. Students at position two see

TABLE 1
Perry's Scheme of Epistemological Development

Perry Position	*Knowledge**	*Learning*
1 - Basic Dualism (hypothetical)	Knowledge is right or wrong, a collection of facts.	Receive right answers from authority.
2 - Multiplicity Pre?legitimate	Knowledge is generally right or wrong. Complexity or uncertainty is either an error or a teaching tool.	Authorities are the source of right answers or give us problems so we can learn to find the Truth.
3 - Multiplicity Legitimate but Subordinate	Knowledge is right or wrong, and some knowledge is unknown temporarily.	Authority is the source of answers or the source of method to find the answers.
4 - Multiplicity	Some knowledge is right or wrong, but most is not yet known. Where authorities do not know, everyone is entitled to their own opinion.	Authorities are the source of ways to think.
5 - Contextual Relativism	Most knowledge is contextual and can be judged qualitatively.	Student learns methods and criteria of his/her discipline. Metacognition begins.
6 - Commitment Foreseen	Knowledge is not absolute but student accepts responsibility for making judgments.	Student accepts responsibility for making a commitment based on his/her values.
7, 8 and 9- Commitment within Relativism	Commitments made within a relativistic world as an affirmation of one's own identity.	Choices made in the face of legitimate alternatives and after experiencing genuine doubt.

* Note. Adapted from Perry (1970).

things as us versus them, right-versus-wrong and good-versus-bad. First-year college students who are often at this level (Pavelich & Moore, 1993; Eaton, et al. 1995) recognize that multiple points of view may exist but generally attribute this to a shortcoming in the authority. Students at this level working on an open-ended design project may be disturbed or shocked that neither the client nor the professor has a definite answer to the problem at hand.

At level three, multiplicity subordinate, students acknowledge diversity of ideas as legitimate but believe that this uncertainty is temporary. In position three, students still believe that Truth (capitalized here to indicate a perspective that something is absolutely or universally true) is out there, but we just have not found it yet. While this change in thinking does not affect students' view of truth—things are still right and wrong—it does raise questions about authority's relationship to truth. Now, instead of expecting to be graded on whether their work is right or wrong, students perceive the evaluation of their work as based on adherence to a procedure for finding the Truth which, of course, is learned from authority. In working through an open-ended problem, students in position three may be willing to suspend temporarily their desire for a right answer, but still will search for the right procedure for finding the answer (e.g. “Professor Smith wants me to do the problem *this* way!”).

In position four, called multiplicity, students accept multiple points of view and the absence of concrete answers. Knowledge and values still are seen in bifurcated terms, but more complex ones than at positions two or three. Knowledge is divided into two realms: (a) things that are definitely known as right or wrong, and (b) things that are uncertain or that are represented by a multiplicity of views. Students in position four become more adept at using evidence. They do not see evidence as a consequence of knowledge and its sources, however, but rather as an exercise in “how we should think.” Students may believe that all opinions are equally valid and, therefore, do not develop a commitment to one particular decision or course of action. A project team of students in this position might develop a good case for one solution but would not fully explore other alternatives (Pavelich & Moore, 1993).

Students make a significant transition in thinking as they move from position four to position five. In position five, students relinquish their earlier dualistic views of the world and accept knowledge as, for the most part, transient and contextual. Simultaneously, students transform their perspective on authority and themselves as learners. Students can now accept themselves as one among many legitimate sources of knowledge. In doing so, they forego their former view of instructors as absolute authorities. Students now see teachers as fellow seekers in a relativistic world who have legitimate claims to authority based upon experience and expertise. In this position, students become comfortable making qualitative judgments among a variety of alternatives.

In position six, the fluidity of this newfound relativism begins to dissolve into an uneasy sense of personal disorientation. If knowledge is in a continual state of flux, who am I as a knower? And, what can I know? At this position, students become aware that they must affirm their own place within the changing contexts of a relativistic world, and that there is a need for commitment to decisions they are making. In a sense, students become committed to making a commitment, although they have not yet reached the point of declaring a choice. As they move into position seven, then, students make an initial, self-affirming decision. For example, a student choosing between graduate work in molecular biology and medical school will understand that he or she will view the human body from different disciplinary vantage points should he or she choose a career as a biological researcher or a medical doctor. This initial commitment is different from earlier choices based upon dualistic visions of the world because it is made after examining legitimate alternatives and after experiencing genuine doubt. In positions eight and nine, this initial commitment gives way to a cycle of commitments, where students learn to prioritize various types of commitments, balancing stability and flexibility. Students may reach these positions as they progress through college.

One vision for the most effective online learning environments of the future would be that they strive to scaffold and support maximal intellectual development of their learners. Gardner (1998) suggests that both prospective employers and the college graduates themselves agree that although students may show strength in their major content areas, they "lack competencies to handle successfully the principal complex issues of work: interpersonal communication, teamwork, applied problem solving, time management, setting priorities, and taking initiative" (p. 61). The characteristics of individuals with the higher levels of epistemic beliefs (e.g. five and above) are the characteristics we would like to see in our graduates and in the workforce. Such individuals are more likely to be able to think through a complex, ill-structured problem, in context, and make a reasonable argument for the best of many solutions—a skill that embodies what is needed in many workforce positions today.

So what is known about the epistemic beliefs of our learners? Multiple research projects conducted at several universities have found that first-year college students are most often at level two, multiplicity pre-legitimate (Pavelich & Moore, 1993; Marra, Palmer & Litzinger, 2000; Eaton, et al. 1995). Further, many graduating seniors do not reach the mature development of contextual relativism (Perry position five), but rather still hold predominantly multiplistic views at levels four or even three (Wise, Lee, Litzinger, Marra & Palmer, in press; Pavelich & Moore, 1993).

Why are students' epistemic beliefs so naïve? Traditional approaches to K-12 and undergraduate education systemically reinforce naïve epistemic beliefs. Further, the bulk of current online learning environments simply replicate the worst of face-to-face methodologies. The teach-and-test ontology engaged in most face-to-face environments as well as online ones requires learners to assume absolutist beliefs about knowledge. Students who adopt more mature intellectual beliefs may not succeed in terms of common metrics such as grades in these environments. Truth is defined by the teacher, and knowledge is a process of memorizing and attempting to comprehend what the teacher or professor says. Questioning the statements or beliefs of a teacher is too often punished. Students are clearly rewarded for employing naïve beliefs. A review of limited research on the relationships between epistemic beliefs, learning, and instruction is presented in the next section.

RESEARCH ON EPISTEMIC BELIEFS AND INSTRUCTIONAL INTERVENTIONS

If the underlying principle of developing epistemic beliefs is to be applied to online learning, then it is necessary to understand the basic tenets of the research concerning epistemic beliefs and learning activities and interventions. A small body of research has examined the relationship of epistemological development and different instructional methods. Some research has confirmed that instructional methods can affect learners' levels of epistemic beliefs. For example, Stephenson and Hunt (1977) developed a course-based intervention around the Perry scheme to encourage first-year students to move from dualist positions to a more relativistic stage. This type of intervention tacitly, if not explicitly, assumes that intellectual development occurs as a result of "cognitive conflict or dissonance, which forces individuals to alter the constructs they have used to reason about certain situations" (Widick, Knefelkamp, & Parker, 1975, p. 291). The freshman social science course was designed to emphasize content that challenged students' typically dualistic values in a supportive teaching environment and to move them towards relativistic thinking. On pre- and post-tests on the Perry scale, the students in the experimental course section showed substantially greater movement than their counterparts in the control (mean change of +.85 versus +.25).

Pascarella and Terenzini (1991) describe two other studies that examined whether course interventions specifically aimed at students' cognitive development encourage advancement on the Perry scale (Knefelkamp, 1974; Widick, Knefelcamp & Parker, 1975; Widick & Simpson, 1978). Similar to the Stephenson and Hunt study, both of these course interventions designed instruction to match and advance students' current intellectual development stages. In one intervention there was a pre- to post-course gain of slightly more than .75 of Perry stage. The second study found that a greater percentage of the students in the experimental section showed growth on the Perry scale than those in the control (63 percent versus 51.5 percent).

Marra, Palmer and Litzinger (2000) also report a statistically significant impact on Perry ratings from a single course although, unlike the prior studies, this research was not structured to intentionally affect Perry ratings. In a sample of first-year engineering students, those who completed a first-year design course on average were rated statistically higher than their counterparts who listened to lectures (3.29 versus 2.9). The researchers noted that the first-year design course is a project-focused, active-learning course where students spend time during class working in their teams and interacting with their instructors in a student-coach type relationship. Even though the course may not have been designed specifically to promote intellectual development, the authors concluded that the challenges inherent in an open-ended design project and team-based curriculum may provide the type of intellectual environment that stimulates students' natural progression toward more complex thinking.

THE CURRENT SITUATION

So far, this paper has described the Perry model—a representative theory of intellectual development, an overview of the research on intellectual development and instructional interventions and established the need for supporting intellectual growth in all learning situations, including online environments. This section examines the current state of online learning environments for their potential impact on epistemic development. Although this discussion could take the form of a review of current pedagogical approaches used in online learning, it focuses instead, on the underlying tools that online courseware packages offer course developers, course facilitators or instructors and students and how these relate to supporting learners' epistemic development.

The most meaningful forms of learning outcomes and the ones that prior research has shown to impact epistemic development positively include modeling, designing, and decision making in a supportive environment related to problem solving (Jonassen, 2000; Marra et al, 2000; Stephenson & Hunt, 1977). In their review of online learning packages, Marra and Jonassen (in press) report that very few online learning environments engage learners in these outcomes. Rather, most online learning replicates in structure and function traditional classroom instruction. The authors argue that a major reason that these meaningful outcomes are not commonly adopted in online learning contexts is that the affordances of online course development, delivery, and management systems do not support them. Marra and Jonassen describe three major limitations (see Figure 1) of online learning systems that create significant barriers to implementing meaningful learning principles in online courses.

Although their arguments are aimed at the limitations of online learning for supporting constructivist-learning environments, the same concerns apply for online learning to support epistemic development. Re-examining the research studies that showed how instructional interventions can impact levels of epistemic development (Marra et al, 2000; Stephenson & Hunt, 1977) one finds that the functionality listed above as "limitations of online learning environments" is arguably critical to online learning environments that can support epistemological growth.

The first item from Figure 1, the lack of an ability to represent knowledge easily in multiple ways, can be related directly to the lower levels of epistemic beliefs. This lack of functionality supports the belief structures of students who are predominantly dualistic or multiplistic pre-legimate by allowing students to continue to believe that knowledge can be represented in only single and simple ways. Conversely, if students were encouraged and required to explore multiple knowledge representations that help learners depict a domain in many ways (e.g. representing knowledge via concept maps or other mind tools (Jonassen, 2000)), they would be more likely to uncover multiple perspectives associated with the

1. The ability to efficiently and effectively accommodate multiple, alternative forms of student knowledge representation. They argue meaningful learning activities require multiple modes of representing what students know (Jonassen & Carr, 2000); however, online course systems support only quizzes, online discussions with no evaluative support, and the submission of word-processing documents.
2. The ability to support distributed tools for meaning making. Although face-to-face courses easily provide access to cognitive tools via laboratory instruction, online course developers who require this functionality to support learning find it difficult to provide access to tools and to support the learning of the tools.
3. The ability to provide and support authentic assessment (either with tools for the instructor or tools to help communicate these assessment data to students). Online learning environments rely predominantly on quizzes and tests, and this over-reliance on single forms of assessment (especially quizzes) precludes the assessment of meaningful learning.

FIGURE 1
Limitations of Online Learning Environments

knowledge. Such revelations are the beginnings of understanding the diversity and complexity of knowledge in any domain—and this understanding is necessary to move students beyond dualistic beliefs and towards a more contextually relativistic understanding of the world.

A similar argument can be made for item two—lack of distributed tools to support meaning making. Once again, such tools allow learners to explore knowledge domains in ways that can encourage deep and critical thinking. These tools—whether they be physical laboratory tools such as microscopes, or software tools such as statistical analysis or expert system applications—provide students access to instructional methods that require them to explore the relationships between concepts in a domain, and allow them to experiment with multiple solutions to a problem and then explore those solution possibilities for strengths and weaknesses. Think, for instance, of a design laboratory where engineering students faced with an open-ended design problem can prototype solutions and then evaluate them based upon relevant criteria. This is, in fact, just the type of experience that was found to contribute to students' epistemic growth (Marra, et al, 2000).

The lack of flexible and multiple forms of assessments (item three) also can impact the possibility of epistemological growth in online environments. Learners usually are motivated to perform to the level of their expected assessments. From their review of course management systems, Marra and Jonassen (in press) found that the general trend in assessment functions for online course delivery packages

Concepts are descriptive of content domain (breadth of net)	
4 points	Map includes all important concepts; describes domain on multiple levels
3 points	Map includes most important concepts; describes domain on limited number of levels
2 points	Map includes numerous concepts; important concepts missing; describes domain on only one level
1 point	Map includes minimum concepts with many important concepts missing
0 points	Failure to complete the assignment
Embeddedness and interconnectedness	
4 points	All concepts interlinked with several other concepts
3 points	Most concepts interlinked with 3 or more other concepts
2 points	Several concepts linked to only one or two other concepts
1 point	Most concepts linked to only one or two other concepts
0 points	Failure to complete the assignment
Links are descriptive	
4 points	Links succinctly, accurately describe all relationships
3 points	Links are descriptive and valid for most relationships
2 points	Some links unclear or vague; some invalid or unclear
1 point	Links are vague; show inconsistent relationships
0 points	Failure to complete the assignment
Links are efficient (parsimonious, no more nor less than necessary)	
4 points	Each link type is distinct from all others, clearly describes relationship; used consistently
3 points	Most links are distinct from others; discriminate concepts; present variety of relationships; used fairly consistently
2 points	Several links are synonymous; don't discriminate concepts well; don't show a variety of relationships; used inconsistently
1 point	Most links synonymous or vaguely describe relationships and aren't distinct from other links
0 points	Failure to complete the assignment

FIGURE 2
Sample Rubric (for Concept Mapping Assignment).

is to offer tools to create and manage quizzes or tests and surveys. Quizzes and tests can include completion, ordering, matching, multiple choice, true/false, or short answer or essay type questions. Of course, these types of predominantly objective test items *can* assess high levels of learning, but such items are difficult to write and, thus, the predominance of objective items assess lower level outcomes such as recall. Naturally, many instructors use these built-in tools for their online courses. Further, if learners know that they will be assessed strictly with objective items that test recall and other lower level types of knowledge, they are not likely to be encouraged to explore a domain in a manner that will impact intellectual development in a lasting way. Conversely, rich performance assessments supported by rubrics such as shown in Figure 2, that require learners to demonstrate their abilities to solve problems and that focus on knowledge relationships, can encourage more in-depth exploration of a knowledge domain, which may lead to epistemic growth.

EMERGENT INNOVATIONS FOR SUPPORTING EPISTEMIC DEVELOPMENT

The previous section described the limitations of the pedagogical methods used by the most popular online learning courseware packages. This section examines a sample of emerging online tools and pedagogical methods that embody the characteristics needed in future online environments that would support epistemic development and address some of these limitations.

Online Conversation Tools

Online conversation tools, often referred to as the "discussion board" or "discussion forum," are the backbone of most of today's online learning environments. Course developers rely on this functionality for designing numerous learning activities. Instructors use discussion boards to simulate the face-to-face meeting time that is missing from online courses. Further, students use these tools to learn from their peers and instructors, exchange ideas, and otherwise fulfill course requirements. These online conversation tools are arguably one of the main "representation forms" available to students, instructors, and course facilitators in an online environment. For something that is so central to online learning environments, many current online courseware packages offer very little functionality in these tools to support *meaningful* conversations and interchanges.

The typical discussion board tool allows for the creation of multiple forums so that different topics can be addressed in different forums. Within each forum users engage in a hierarchically structured "threaded" discussion activity. The threaded discussion shows the list of all the messages with headings, so learners do not have to search through old messages unrelated to the discussion topic. In a typical use of the threaded discussion, an instructor specifies a topic heading in advance and has learners associate their input such as opinions, messages, or issues with the topic. Their inputs are organized around topics and subtopics (Klemm & Snell, 1998) that emerge in the discussion. That is, the discussion is not prestructured. Current reviews of online courseware packages show that the vast majority (17/20 or 85%) supports a threaded discussion function (Marshall University Center for Instructional Technology, n.d.). Research in this relatively new area of the use of threaded discussions is beginning to show that threaded discussion activities result in low-level, sharing and comparing interactions rather than high-level negotiation of meaning or knowledge construction interactions (Gunawardena, Lowe, & Anderson, 1997; Kanuka & Anderson, 1998; send Les other citation).

Many researchers are seeking to foster online discussions that move beyond these surface-level discussions to ones that will contribute to real meaning making (Jonassen & Remidez, in press; Gunawardena, Lowe, &

Anderson, 1997; Anderson, 1996). I further posit that such conversations around an intellectually challenging topic have the potential to call into question learners' existing epistemic beliefs and help them to see both the current topic and knowledge in general in a different and more intellectually advanced way. Take the following as a counter-example. With the oft-used threaded discussion, students who are predominantly multiplistic or even dualistic (both common lower epistemic levels for college learners) may engage in threaded forums as part of course requirements while not expecting to learn much from their peers since such learners still seek answers and truth predominantly from authority figures. Threaded discussions, which by their very nature are not pre-structured and do not require the posting participant to back up his or her claims with evidence that might sway readers to the posted view point, offer little possibility for influencing the epistemic beliefs of other learners. Rather, as prior research has borne out (Gunawardena, Lowe, & Anderson, 1997; Kanuka & Anderson, 1998), students can post either shallowly supported claims or replies that often consist mainly of "I agree" or "I disagree" and perhaps a reason why. Unfortunately, many of those efforts are effective only marginally because the students do not construct shared knowledge through discourse processes about the activities. They may learn how to cooperate adequately through division of labor, but socially constructing shared meaning about their activities requires that they know how to discuss their activities in meaningful ways. More often than not, students do not possess these skills, largely because they have seldom been encouraged or required to discuss meaningfully what they are doing. Student opinions are not sought or valued.

An alternative type of tool, constraint-based conversation tools, is beginning to address this problem and as such offer significant possibilities for positively influencing epistemic development. Constraint-based conversation tools are pre-structured forms of conversation systems that impose different conversational or argumentation structures onto the discussion and, thus, offer learners an alternative way to represent and build knowledge. These structures make explicit the constraints involved in the conversation, and users are forced to participate in the discussion according to these pre-defined constraints or rules. The Belvedere environment, for example, provides four predefined argumentation constraints ("hypothesis," "data," "principles," and "unspecified") and three links ("for," "against," and "and") (Suthers, 1998). These constraints form the links or a relation between the ideas that conversants produce.

Many constraint-based systems have graphical interfaces that utilize node-link graphs representing argumentation structures. Like semantic networking tools that provide visual and textual instruments for developing concept maps, these graphical interfaces provide learners with a visualization of an argument, so they can view the entire argument and manipulate it with ease (Suthers, 1998). Visualizing argumentation enables students and instructors to see its structure, thus facilitating its more rigorous construction and subsequent communication (Buckingham Shum et al., 1997) as well as helping learners visualize and identify "the important ideas in a debate" (Suthers & Jones, 1997). As with the Belvedere environment, most constraint-based systems limit users to one pre-defined structure (Suthers, 1998). Most recently, Jonassen and Remidez (2002) have introduced a new online conversation environment that can be adapted to support alternative discourse structures.

When creating a new scaffold forum in the environment described by Jonassen and Remidez, instructors must enter a title and description for the forum and define the message types from which the student will be able to choose (for example: Problem, Solution Proposal, Support Proposal, etc.). After specifying all the message types, the third step is to create the input format for each message type. For example, an instructor can specify that all problem statements should be composed of a

TABLE 2
Discourse Structure Being Used in Initial Testing of Scaffolded Discourse Environment.

Problem Level	
	Problem Statement
Proposal Level	
	Solution Proposal
	Position Statement
	Administration Policy or Law
Warrant Level	
	Support Proposal
	Clarify/Re-interpret Proposal
	Rebut/Reject Proposal
	Problem Redefinition Proposal
Evidence Level	
	Facts/Statistics/Evidence
	Personal Opinion/Belief
	Personal Experience/Observation
	Theory/Law
	Other's Experience
	Common Knowledge

text block labeled “Problem Statement.” The fourth step is to specify the relationships between the message types. The instructor specifies the message type relationships by checking which message types are allowed to respond to other message types. For example, the discourse structure that the researchers are currently testing defines 14 types of statements (see Table 2).

Prior research concerning epistemic development indicates the importance of scaffolding or supporting students’ intellectual development (Marra, et al, 2000; Stephenson & Hunt, 1977). Constraint-based conversation tools can provide just that needed support. Students typically are not adept at producing sound arguments. Constraint-based systems can guide them through the process of argument creation, support, clarification, refinement, rebuttal, etc. Such a supportive environment could influence epistemic beliefs in two ways. First, the student who creates the argument must begin to use evidence to support his or her positions rather than simply relying on an opinion or a hunch. This directly challenges a student who holds dualist or multiplistic belief systems to go beyond the opinion-based decision-making processes that are characteristic of the lower levels of intellectual development. Similarly, a learner who either reads such structured arguments may be more likely (than in a threaded discussion) to be confronted with strongly supported arguments that are presented in clear ways that are easy to follow. This presentation both allows students to analyze better the given argument, determine how it fits with his or her current knowledge structures, and potentially challenge his or her current beliefs about the topic. Lastly, this type of discussion structure has the possibility to present students with multiple perspectives on a single topic. Clearly, this can be associated with multiplistic intellectual development beliefs. However, because these discussion systems require that their perspectives be backed up by evidence of different forms, students reading such arguments may begin to realize that a) multiple perspectives exist in this domain, b) these multiple perspectives are more than simply an individual’s opinion but rather are supported by various types of evidence, and c) one can choose a “best” argument by weighing the relative evidence and sources. This last possibility is a necessary component of advanced intellectual development, and although the argumentation system itself may not force the making of such choices, the presence of the visually structured and evidentiary supported arguments would allow a facilitator to encourage such evaluation activities as part of the discussion.

Quality Online Assessment Tools

Constraint-based online discussion tools may address the need for alternative knowledge representations in online environments. Alternative assessment tools are also needed in online environments to help promote epistemic development. As stated previously, learners in general are motivated to perform to the level of their expected assessments. Marra and Jonassen (2001) found that course management packages do a good job of helping instructors to create and manage quizzes, tests, and surveys, and of providing tools to report the summative quantitative data for each student on each graded item (e.g. online gradebook). However, if an instructor wishes to conduct performance assessments of student activities, the online packages have little to offer. Depending on the form of the performance required (e.g. word processing document, semantic network, expert system), the online package may or may not support easy means of submitting these documents to workspaces where instructors can retrieve and then score them. Regardless of that, course management packages do not support the creation or management of rubrics for assessing performance activities. Certainly instructors can and do work around this lack of functionality; however, this lack of built-in functionality implies a pedagogy that supports lower-level learning outcomes.

Although a review of the literature and current online course management tools did not produce a rubric creation and/or management tool in any of today's online course environments (Center for Curriculum Transfer and Technology, n.d.; Marshall University Center for Instructional Technology, n.d), there are such tools available, one of which is "The Rubric Processor" (http://insys.ed.psu.edu/~lin/Rubric/H_rubric.htm). This tool helps its users to create assessments that align with performance-orientated environments and promotes communication through assessment to guide instruction. The Rubric Processor has four parts: a bank of existing rubrics, a tool that helps users to create new rubrics, an interface to guide assessing a student's performance using a specific rubric, and the ability to create and print a final report reflecting the assessment process. The creators of the Rubric Processor realized both that (a) performance assessments are often the most valid and meaningful types of assessments for many complex learning outcomes, and (b) creating and managing large quantities of rubrics effectively so they communicate results to learners and other stakeholders can be a time-consuming and burdensome process. The first item establishes the need for performance assessments—and also that the use of performance assessments that by their very nature are designed to assess higher levels of learning outcomes may help jog students from their low epistemological beliefs. Just as importantly, the second realization is the very impediment that may prohibit instructors from effective utilization of rubrics.

The Rubric Processor addresses the second concern via its four function areas. For instance, to help users create a rubric, the tool guides users through the following steps. The examples provided in parentheses are all for a persuasive speech rubric.

- Specifying and defining the major elements of the rubric (e.g. content appropriate for audience, sequencing of message, etc.),
- Defining the various rating levels that are allowable for each element (e.g. novice, expert),
- Defining what leach level means (e.g. a novice in terms of sequencing of the message demonstrates . . . .), and
- Defining remedial feedback for each applicable level that is then used in the report generator portion of the Rubric Processor.

The reader may refer to Rubric Processor's web site (http://insys.ed.psu.edu/~lin/Rubric/H_rubric.htm) for further details on its other functions.

The Rubric processor is a stand-alone tool that represents the functionality that would be desirable to integrate in the online course management packages of the future. Additionally, such packages should integrate these performance assessment tools with existing functions such as the course grade book. For instance, once the rubric is created using a scaffolded tool such as what is offered in The Rubric Processor, the rubric could be set up as a template allowing an instructor to simply apply that rubric for each student's work. Further, the online package would store each student's completed rubric in a "private" area readable only by that student and the instructor and automatically update the appropriate cell in the grade book with the student's score. Similarly, students could access their completed rubric by simply selecting the numerical score posted in the grade book. This would then pull up a student's rubric for that assignment with more information on why that score was earned, as well as individual comments clarifying the grade earned. This would not only be easier for the instructor but more importantly in terms of encouraging epistemic growth for learners, it would (a) provide *qualitative* assessment feedback on complex tasks that challenge lower-level epistemic beliefs simply because the complex nature of the tasks requires students to think in deeper ways about the domain, and (b) make the use of complex performance tasks easier to implement and support for instructors, thus providing learners with the types of complex problems that can encourage epistemic growth.

A Course Management Package to Support Epistemological Development

A course management environment for online learning, called TeleTOP (http://teletop.edte.utwente.nl; Collis & Moonen, 2001), developed at the University of Twente in the Netherlands demonstrates additional functionality that could provide alternative knowledge representation methods in an online environment and support epistemic growth. The creators of TeleTOP describe the system as not so much a course management system but a "flexible way to make use of a database" (Collis, 2001, p. 316)—which is the foundation of the environment's software architecture. TeleTOP differs from other course management systems as it is designed around a specific pedagogy—that of "learning from experiences" (Collis, 2001). Collis operationalizes this phrase by contrasting "learning from experiences" to "learning from content transfer"—which would describe many typical online learning environments. So, where in a "content" system, "content is pre-selected, pre-structured and delivered" (p. 313), in an "experiences" system, content comes from a variety of sources, much of it from the learners themselves.

This focus on learner contributions and learner-led instruction is what makes TeleTOP a current emerging technology that we should consider as we move towards the online learning environments of the future and search for online strategies that contribute to epistemic development. TeleTOP allows students to contribute to, and in many ways *build* the content of the course. For the most part, students' learning activities are built around bringing new resources to the learning setting. Just as with the other emerging techniques reviewed in this section, the strategies and capabilities in TeleTOP have the potential to positively impact epistemic development. As Collis (2001) indicates, with traditional course management systems, students are presented with a pre-defined set of content, and students are passive receivers of this content. Such a strategy inherently (if not explicitly) implies that this content is "correct" and represents the viewpoints and beliefs that learners should adopt. Clearly, this aligns with the lower levels of epistemological development—dualism and multiplicity. In contrast, the TeleTOP system and the pedagogical methods employed with it as described by Collis (2001) reinforce higher levels of epistemological development.

In her discussion of strategies associated with the technology, Collis recommends not only that courses focus on learner contributions but that all contributions be made "visible" and "valuable" (p. 315) and that the overall environment should be used to bring together different views from a variety of perspectives: instructional designers, instructors, learners, and experts. Such an environment that provides many perspectives in a domain has a strong possibility, when coupled with appropriate instructor facilitation, to challenge students' dualistic beliefs. Further, Collis also describes an activity where students and instructors evaluate these resources in order to determine which contributed resources are suitable for "re-use" in that course or future activities. This type of collaborative evaluation of the contributions can help learners move beyond simply the multiplistic idea of the existence of multiple views to a stance where learners can judge one view as better than another based upon established criteria. This type of thinking is indicative of the contextual relativistic learner—one who has reached the higher levels of epistemological development.

SUMMARY AND VISION

The prior two sections examined the concept of encouraging epistemological development in the online learning environments via explorations of the key limitations of the current popular online learning environments and examples of emerging technologies and techniques that are representative of functionality that could support learner epistemic development in online environments. The limitations of the current environments included limited forms of knowledge representations, assessment techniques predominantly limited to quizzes of objective items, and the lack of support for distributed tools for meaning making (see Figure 1). All of these limitations can potentially contribute to dualism or low levels of multiplicitous views—both on the low end of the intellectual development spectrum.

In contrast, tools such as the scaffolded constraint-based discussion tool (Jonassen & Remidez, 2002), the Rubric Processor, and TeleTOP (Collis, 2001) offer functions that could support a learner's epistemological development. I do not claim that this is a complete list of such tools; however, the characteristics that these examples embody (listed below) can lead us towards the online education environment of the future.

- Support for scaffolded participation in online discussions that are constraint-based (versus simple threaded discussions).
- Support of tools that include functionality for meaningful assessment of student work (e.g. performance assessment and rubric tools).
- Easily allow students to contribute content resources to the overall learning environment
- Allows students easy access to tools for doing alternative knowledge representation
- Support via built-in tools the examination and re-use of selected student contributions, thus resulting in students engaging in evaluative activities associated with learning.

The essence of epistemic development is that learners' understandings of what knowledge is and where it comes from matures from the simplistic dualistic thinking to an understanding that all knowledge must exist in the context in which it is to be used or applied (Hofer & Pintrich, 1997). The above-mentioned tools allow for rich representations of knowledge in multiple forms and are coupled with appropriate support for helping learners both learn to contribute more to a common, developing course knowledge base (via sophisticated discussion tools, knowledge contribution tools and complex performance assessments) as well as learn to evaluate and judge contributions based upon their merit in the relevant context. In general, these functions when used in a supportive environment created by the course facilitator could help challenge learners' dualist or low-level multiplistic epistemic beliefs as the learners are presented with the ability to address complex problems with multiple solutions in their online learning environments.

There are many potential ways the ideal online learning environment of the future could be implemented in order to support these functions. However, two current examples of online management systems seem to embody the future of such environments. Both TeleTOP, the system previously discussed from the University of Twente, and a system called the

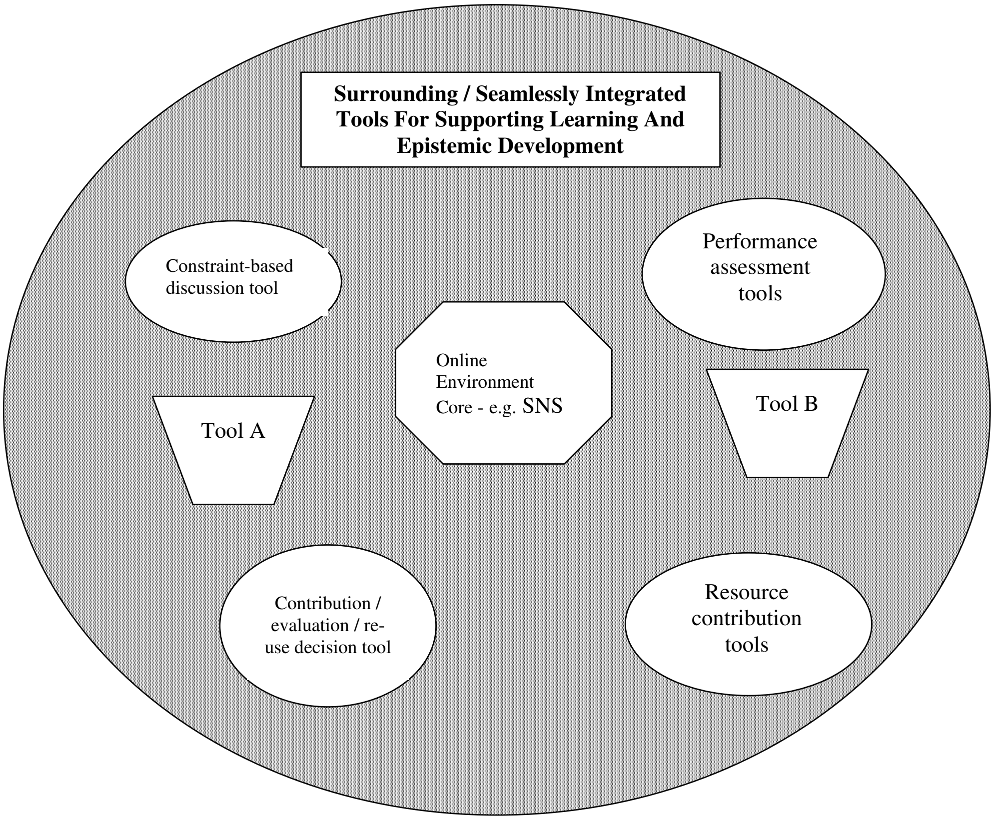

FIGURE 3
Online Environment Representation

Shadow netWorkspace™ (SNS) (http://sns.internetschools.org) from the University of Missouri are open architecture systems that are more representative of operating systems than traditional course management systems.

SNS is a Web-based work environment designed and developed to support schools and universities. Much like a personal computer's desktop, SNS rovides a personal workspace for organizing, storing, and accessing files and an environment for running applications (Jonassen & Remediz, 2001). SNS has an Application Programming Interface (API) so others can develop applications for it, and is freely available under the open source (GNU Public License) so that anyone can participate in enhancing and supporting it. Because SNS is not already full of pre-determined online education features (e.g. a particular type of discussion board), current and future users have the possibility of creating the functionality they need to support their desired pedagogical approaches. For instance, the Shadow system is the basis for the development of the constraint-based discussion tool described in the previous section, and SNS's API interface provides a platform for development of other pedagogical tools.

Figure 3 depicts at a high level how an overall system for supporting online learning that encourages epistemic development based on an SNS-like underpinning might appear. Conceptually, the environment is very simple. A central core such as the SNS would be the basis for this system and provide the underlying support and inter-application communication for the tools that surround that core. It is, in actuality, the "glue" that would hold the system together. This central core, which in effect functions like an operating system, would then be surrounded with appropriate tools or applications for supporting learning in an environment that encourages epistemic growth. In addition to the tools already discussed and pictured, there might be other tools that could promote epistemic development such as seamless access to constructivist learning environments, or specific computer-based tools, or Mindtools (Jonassen, 2000), that would allow learners to represent in may forms what they know.

Overall, a learner would be presented with a suite of, if you will, performance tools for engaging in learning activities that address complex problems and thus potentially support epistemic development. Although current online learning environments may in no way prohibit these types of activities, they also in no way *support* or *enable* them. Some may argue this is a minor difference. However, in a climate where online course developers are often faculty members who receive no extra compensation or reduction in other duties to develop an online version of their current face-to-face courses, providing a set of easy-to-use tools that make complex and meaningful learning activities easy to implement (or at least easier) in an online environment may make the difference between engaging students in online activities that can encourage epistemic development or not.

CONCLUSIONS

In this paper, I have argued that the most effective online learning environments of the future will strive to scaffold and support maximal intellectual development of their learners. This argument is based upon prior research that indicates that most students come into higher education at fairly low levels of epistemic development (Marra, Palmer, & Litzinger, 1998; Pavelich & Moore, 1996) and further that promoting advanced levels of epistemic development will help learners perform the problem solving and decision-making tasks that are prevalent in today's work world.

This discussion has taken place in the context of online learning environments of the future and what they should strive to be. Despite the limitations of current online environments (Marra & Jonassen, 2001) that support content-based and transmission online educational experiences, there is good reason to hope for much-improved online environments in the future. For instance, this author was able to identify easily several examples of pedagogically advanced tools for supporting online learning that are designed to support higher order and complex learning outcomes and may arguably contribute to learners' epistemic growth. Even though these tools are not yet available in one cohesive online course support package, with the advent of such systems as SNS and TeleTOP, there is not reason to believe that such an integrated package may not exist in the relatively near future.

Having said this, it would be naïve to imply that just having these tools available would be enough to create the maximally effective online learning environments that encourage and support epistemic growth. These new tools represent pedagogical changes for many course developers, instructors, and (let's not forget) students. Even when the tools are readily available to support these more advanced learning outcomes and epistemological growth, the same sorts of faculty development activities that we currently employ for encouraging change in face-to-face environments will have to be applied for these advanced online environments. Faculty and course developers will need their own scaffolding, training, and support to both make use of these advanced tools in course designs and to provide ongoing effective facilitation of the accompanying activities during the implementation of an online learning experience. Like so many other innovations in education and other disciplines, this paradigm shift represents a huge "systemic change" problem.

Lastly, but certainly not insignificantly, as the adoption of such tools as those described here becomes more prevalent in online environments, there will be the need for rigorous research on the effects of such tool use on learner epistemic development. Prior research concerning the relationship between epistemic development and instructional interventions is quite minimal. As online environments continue to proliferate, which seems a likely scenario, assessing the impact of these tools on creating maximally effective online learning and promoting epistemic growth will provide a rich and hopefully knowledge-enriching research venue.

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