EXPERIENCING THE WORLD THROUGH INTERACTIVE LEARNING ENVIRONMENTS

Agustin A. Araya, San Jose State University

INTRODUCTION

Education is becoming one of the primary targets of the so-called computer and information revolution because of the many opportunities that it offers to the introduction of computing technologies. Applications of these technologies to education have taken many forms including Intelligent Tutoring Systems (Wenger, 1987)—a particular kind of computer-based educational system that emerged from work in Artificial Intelligence—and Interactive Learning Environments (Sack *et al.*, 1992). Enabled by recent technological developments in communications technology, new forms are currently emerging, including Collaboration-Based Environments (Baker *et al.*, 1995) and Internet-Based Learning Environments (Brusilovsky *et al.*, 1996).

What are the possible effects of the massive introduction of these technologies across all levels of education? It is becoming increasingly clear that the use of new kinds of tools in an activity not only produces the intended effects of improving its efficiency, but can alter in unexpected and significant ways the activity itself as well as those involved in it (Borgmann, 1984; Norman, 1993). As technologies become more powerful and more widely used, the need for scrutinizing their unintended effects on people, activities, and communities, becomes more urgent. Within the research community working on computing applications in education, significant critical analyses of these technologies have been made (Clancey, 1993; Sack *et al.*, 1992). For the most part, these criticisms are directed at the limitations of the technologies to achieve what they promise or at the fact that their intended purposes are misguided, with the consequence that they would be supporting the learning of non-crucial skills.

In this work, I focus on potential effects that the intensive use of technologies such as Interactive Learning Environments—taking place in the context of communities increasingly penetrated by all kinds of technologies—

could have *on the users themselves*, specifically, at the fundamental ontological level of how people "open themselves to the world" and "how the world touches them." What we mean by "openness to the world" and what kinds of transformations it could undergo, are issues that require clarification and will be elaborated below. I am not suggesting that the potential effects of interest to us here would only be elicited by learning environments, nor that they would be limited to computing technologies. Since these technologies are an expression of fundamental trends at play in modern technology as a whole, the kinds of effects elicited by them echo the effects of these trends, although, simultaneously, they reshape and deepen them in particular ways.

In this work, I take a few steps in approaching these complex questions and will proceed by examining a specific computer-based, interactive learning environment for learning second languages (Hamburger, 1994a), whose characteristics make it representative of a broad class of such systems. Focusing on how the learning environment appears to users, I uncover properties of its so-called "microworlds," of the user's bodily involvements with them, of the interactive capabilities of the "software tutor," and of the overall learning situation. I then develop an ontological characterization of the learning environment as a whole. Finally, I suggest possible ways in which interactions with this kind of environment could influence the way users experience the world.

PERSPECTIVE AND METHOD

From a hermeneutical perspective, Ihde characterizes the "existential import" of technologies in terms of "world reflexivity," which he describes as follows: "Humans interpret their world in terms of some focused interpretation. . . . But because humans are also existentially and necessarily related to what they perceive as their world, they 'bring it close' so that ultimately they also interpret themselves in terms of their world" (Ihde, 1979, p. 64). As a consequence of world reflexivity—a notion that Ihde later expands (Ihde, 1983) —and because computing technology becomes prominent in many activities, humans tend to interpret themselves in terms of this technology, leading to notions such as "the brain is a computer," and "human intelligence can be simulated by computing machines." Thus, a noticeable effect of this technology is that through processes of self-interpretation and world-reflexivity it affects the views that human users of technology have of themselves and of the world.

A related characterization is offered by Brown and colleagues in the context of a discussion of situated cognition. They state that "the culture and the use of a tool act together to determine the way practitioners see the world; and the way the world appears to them determines the culture's understanding of the world and of the tools" (Brown *et al.*, 1989, p. 33). More explicitly, they indicate that "using [tools] entails both changing the user's view of the world and adopting the belief system of the culture in which they are used."

These characterizations focus on the effects of technology upon the views and beliefs that users have of the world and of themselves. Undoubtedly, these kinds of effects are significant, but we should not overlook the fact that interpretations and beliefs are, in a sense, secondary phenomena, masking underlying phenomena which can be regarded as their "conditions of possibility." That is, prior to interpreting the world and having beliefs about the world it is necessary to be "open to the world." It is this last kind of phenomenon that is of interest to us here.

Openness to the World:

Here we arrive at the domain of what Heidegger has characterized as *fundamental ontology* (Heidegger, 1962, p. 34). While "ontology" refers to the categories that characterize in an essential way entities other than human beings, "fundamental ontology" refers to those categories that pertain specifically to humans. In the context of fundamental ontology, Heidegger was primarily concerned with determining the constitution of human openness to the world, which he captured in the well-known formulation of "being in the world." The central aspect of this constitution, the "being in," refers to a primordial openness which is prior to consciousness, beliefs, and intentionality. Any human "comportment" is rooted in this openness which discloses to us that to which we relate in a comportment. When we engage in activities, which always involve using things and tools of one kind or another, this engagement is possible at all because it is grounded in such "being in the world."

We can now state more precisely the question we want to raise about the technology of Interactive Learning Environments, which we have also raised with respect to other emerging technologies (Araya, 1995a and 1996), as follows. Assuming that, in the context of communities increasingly penetrated by all kinds of technologies, the intensive and massive use of technologies such as interactive learning environments could imperceptibly but decidedly influence the way in which the world touches human beings—and, reciprocally, how human beings open themselves to the world—then, what kinds of effects or influences would they be? Such an assumption amounts to suggesting that the use of technology could influence the character of the openness itself. We now examine this assumption more closely.

At a later stage in his work, Heidegger realized that the fundamental structure of "being in the world," which characterizes human beings in an essential way, had a historical character. At the risk of greatly simplifying and combining together issues that emerged at different stages in Heidegger's thinking, we can say that this fundamental openness is historical in the sense that what is disclosed in the openness—the way in which the world appears to us or is revealed—has an epochal character. Heidegger introduces the notion, "mode of revealing," to refer to the way in which the world is revealed in the openness, and proposes that differences in the mode of revealing determine different historical epochs (Heidegger, 1973). As is well known, in "The Question Concerning Technology," Heidegger (1977) suggested that, *essentially*, modern technology is a particular mode of revealing. In consequence, although openness continues to be an essential trait of human beings, the way in which the world emerges in openness may be radically different in different epochs.

It then becomes possible and necessary to formulate a question about the origin of the different modes of revealing—that is, a question about the kinds of phenomena that could underlie the changes in the way in which the world is primordially revealed. How could we account for these changes? If, in attempting to approach this difficult question, we look for indications in Heidegger's own work, what we find is a profoundly speculative line of inquiry which will be of no immediate interest to us here.

Transformations of the Openness to the World:

We are then led to suggest that the mode of revealing which makes the world appear to us in certain ways, *is not an ultra-stable ground*; rather, it is constantly "under construction." And what we do and the kinds of activities we engage in have an effect upon that ground. More specifically, I suggest that the way in which the world appears to us in these activities, or, informally, how we experience the world through them, influences the way in which the world in general appears to us. It seems unlikely that the mode of revealing, which is such a fundamental ground, could be profoundly transformed by singular events. Most likely, noticeable transformations would be caused by the continuous and protracted accumulation of unnoticeable changes.

In any activity, we are involved with a Heideggerian "totality of equipment" from which we select particular tools for achieving specific tasks. While using a tool we become bodily involved with it and, possibly, with other users or participants in the activity, with materials required by it, and with our surroundings. Throughout these bodily involvements we remain, so to speak, anchored in the fundamental ground of a particular mode of revealing. At the same time, through these bodily engagements, the world appears to us in a certain way; we experience it in a particular manner. This, I suggest, could affect, however subtly, the particular character of our openness.

In periods of intense technological innovation drastic changes may occur: (i) changes in the tools used in an activity, including the introduction of entirely new kinds of tools; (ii) changes in users' interactions with the tools, including the emergence of new kinds of interactions; and (iii) changes in the overall character of the activity, as it becomes supported by new tools. Given the increasing power of the technologies used in the development of new kinds of tools and devices, these may be endowed with unheard-of properties, which cannot be easily assimilated to properties of tools and devices already familiar to users. Because of these new kinds of properties, the operations that people perform with them also undergo changes. New kinds of operations may, in turn, lead to new kinds of bodily involvements and may also affect our relationships with the surroundings in subtle ways. (For example, consider the works of Ihde, 1979 and 1983, on effects of using optical instruments and other kinds of devices; of Borgmann, 1984, who characterizes some of these effects in terms of his "device paradigm"; and of Fry, 1993, who conceives of the "televisual" as a new ontological domain.) I suggest, then, that these various kinds of changes may ultimately lead to transformations in the way the world in general appears to us. Our task here, in consequence, is to characterize the kind of world we engage in when dealing with interactive learning environments.

Method of Analysis:

We will examine a particular learning environment, namely, the Fluent system, oriented to supporting the learning of a second language, such as French or Spanish (Hamburger, 1994a and 1994b, hereafter referred to as FSA and FSB, respectively). The Fluent system seeks to immerse students in a meaningful situation where they can engage in "conversation" in the desired language with a "software tutor." A "situation" or "world" is achieved in terms of a microworld, that is, a visual representation of a situation in which both student and tutor can perform operations as well as communicate through typed language (FSA, p. 429).

We proceed by focusing on the following issues. *First*, we examine the microworlds and the user's interactions with them, and raise questions such as: What are the novel characteristics of the "things" that compose the microworlds? What are the novel aspects of the operations performed on these things? What are the characteristics of the user's bodily involvement with microworlds? *Second*, we examine the software tutor—the component of the system in charge of the interactions with the student—addressing issues such as, How is the tutor embodied? What are the bodily interactions between student and tutor? How does the tutor appear to the student? *Third*, we consider how the introduction of the technology of interactive learning environments redefines the overall character of the learning situation, and how this redefinition, in turn, affects the relationships of the learner with the elements of the situation. *Finally*, on the basis of this analysis we will develop an ontological characterization of the interactions the user maintains with the learning environment, which constitutes a description of how the world appears to the student in these interactions.

Throughout the analysis, we will be primarily concerned with a *description* of phenomena rather than with an *explanation* of their causes. In this way, we are better able to address what concerns us here, namely, a characterization of *how* the world appears. Insofar as we emphasize description and certain kinds of phenomena, our method is akin to a "phenomenological method" (Heidegger, 1962, pp. 49-63).

Interactive learning environments occupy an intermediate position between the early and the newly emerging computer-based approaches to the support of education; and there is a good chance that, even if they turn out to be only a transient technological feature, many of their properties—which are dependent on intrinsic characteristics of computing technology—will survive in the newly emerging technologies. To the extent that this turns out to be the case, our analysis should remain pertinent. I selected for analysis the Fluent system because, first, it is a good example of an interactive learning environment (as indicated in Chanier, 1994); and second, its domain of application—in contradistinction to the predominant domains of mathematics, science, and programming—is a non-technical domain. In this type of domain the kinds of potential effects of interest to us appear easier to trace.

Finally, for the analysis, I am relying on published material on the Fluent system and its components (FSA and FSB; Felshin, 1994), as well as on my own familiarity with interactive learning environments (Araya, 1995b). In an attempt to make the analysis relevant to learning environments as a whole, in the analysis of this system I emphasize those aspects that it has in common with other learning environments. It is important to keep in mind that I am not attempting to determine how good or bad the Fluent system is for supporting language learning. Rather, I am interested in examining the kinds of dealings with the world that obtain in that environment. In the course of the analysis I will be pointing out certain characteristics of the environment that could be read as shortcomings of the system. Such limitations are not peculiar to the Fluent system; rather they are intrinsic to the underlying technology and, as such, shared by all environments of its kind.

Although overlapping in some respects, the work presented here has an entirely different aim than critiques of computing technology (in particular, of Artificial Intelligence) as exemplified by Dreyfus (1992) and Searle (1980). While their concern is with the intrinsic inability of such technology to produce "understanding" and "intelligence," my concern here is with the effects of using technology on the users themselves. Lave's (1988) critique of cognition disengaged from practice shows, by extension, the limitations of computer-based learning approaches that are inspired by cognitive models. Clancey (1993) elaborates a wide-ranging critique of intelligent tutoring systems and learning environments from the perspectives of situated cognition and a socio-technical systems approach. Again, although there is some overlap with these critical analyses, the work presented here is not primarily concerned with the effects of technology on the activities in which it is introduced; but, rather, with effects on users themselves.

INTERACTING WITH THE FLUENT LEARNING ENVIRONMENT

Aiming at overcoming limitations of conventional approaches to language learning, the Fluent system seeks to immerse students in a meaningful situation where they can engage in "conversation" with a software tutor (FSA, p. 429). A crucial characteristic of the system is that it allows for multiple language experiences through the selection of a specific microworld, language, and teaching strategy. These capabilities are achieved by using a variety of Artificial Intelligence techniques and tools, including a multi-lingual natural language processing system (Felshin, 1994). As reported (FSA), a first version of the system using a pre-defined combination of its main components had been developed, while a second version, allowing for the selection of these components, was being implemented. We now examine the interactions that users of the system have with the microworlds, the software tutor, and the learning situation as a whole.

Interacting with Microworlds:

Microworlds are stylized, iconic depictions of a situation constituted by an organized collection of familiar "things" disposed in an imaginary three-dimensional "room"—things which can be operated upon by controlling a movable hand via a point-and-click device. A typical microworld depicts a kitchen situation, in which the user can grasp a thing such as a cup, and can perform operations with it, such as moving the cup towards the spigot in a sink and filling the cup with water. All along, various kinds of language interactions between the learner and the software tutor can take place, allowing for a two-medium communication. Users act on the microworld by means of the microworld hand (or micro-hand), depicted as one more element in the microworld. Grasping a thing is accomplished by visiting it with the micro-hand and then pressing and holding the mouse button.

A great deal of effort has been put into the graphical component of the Fluent system, to achieve "fine grained interactivity with the student as well as consistency of the graphics with the underlying microworld situation that it reflects" (FSA, p. 441). Various kinds of animations are used to convey vividly the execution of certain actions, such as pouring water from a cup into an empty pot. It is then fair to say that in interactions with a microworld users have a sense of being engaged in a certain "world," where meaningful actions can be performed, and where, within certain limits, "things happen as expected." In consequence, immersion in a meaningful micro world does take place, which is one of the research objectives of the Fluent project.

Now, we need to ask, what are the characteristics of these kinds of worlds? How does interacting with them differ from interacting with their "real" counterparts? Let us now consider microworld things as objects, outside of their context of usage. Insofar as they appear at a particular time and place in the "room," microworld objects exist in "time" and "space"; they are "real." Because we can perform operations on them, they seem to have a "life of their own." But these objects have a very limited set of mostly visual properties, such as shape, size, and color. Partly because of this, they are almost entirely unaffected by other objects. Although an object passing in front of another partially occludes it, there can be no friction between them. Objects lack fundamental physical properties such as mass and temperature; pouring cold water into a cup or pot does not affect its temperature.

Microworld objects also lack certain kinds of functional and physical properties; for example, they cannot malfunction nor break in the sense that real objects do. Nor do they meaningfully participate in certain kinds of social relationships; for example, they are not owned by anybody. It could be argued that this lack of properties is not an essential limitation of these kinds of objects because some of the missing properties could eventually be added, either using present or future technologies. But I believe we would always be able to point out other still missing properties, for the simple reason that real objects have an inexhaustible set of properties.

In fact, this paucity of properties is due to a fundamental characteristic of these objects; namely, that they are *disembodied objects*. Whatever few properties we perceive of them, they do not emerge from their bodies, which they lack; rather they are computed and displayed in a particular region of space and time, the computer display. It could be argued that the "internal representation" of an object in the underlying software system, which keeps track of the state of the object, would constitute something like its body. But this is clearly different from the physical body of real objects, bodies which have certain properties that we can perceive in ways which are co-determined by the characteristics of our perceptual systems. Considering that these objects, because they are disembodied, can be seen but not touched, we characterize them as *shadow-objects*.

What kinds of relationships obtain between the user's hand and the microworld hand? To reach a cup, a user grasps the mouse with his or her hand, moves the mouse—thus inducing a corresponding movement in the micro hand—and then visits the cup. Thus, the micro hand is a tool that constitutes an extension of the user's hand into the microworld. Extensions of hands and arms are commonly used in many real-world activities, for example, to cut tall branches in a tree by means of a tool consisting of a stick and a cutting device attached to one of its extremes. If the activity goes smoothly, it is as if the stick were fused with our arm and hands, becoming an extension of our body, and the branch itself becomes the focus of the action. Through the cutting device and the stick we sense the stiffness or flexibility of the branch and we can say that through the tool we are "touching" the branch.

But the extension relation with the micro hand has a different character. For a practiced user who has learned to visit a desired object in the microworld, both the mouse and the micro hand withdraw from presence, and the object of the action becomes the focus of the activity. Thus, it may appear that the mouse and the micro hand constitute a single tool, composed of two parts. Considering, however, that the mouse has a body while the micro hand is a disembodied object, it is more appropriate to regard them as being actually two related but distinct tools. In consequence, although the relationship that obtains between the user's hand and the mouse is similar to that between the user's hand and the stick of the previous example, a deep caesura or discontinuity separates the user's hand from the microworld hand. In fact, they belong to different kinds of worlds. The user's hand does not sense the micro hand, as nothing comes back from it through the mouse, nor can the user fully perceive the physical connection between the mouse and the micro hand, as part of it is electronically mediated.

In addition, because the microworld hand itself is a disembodied object, the user cannot sense, through it, the microworld objects. When I "grasp" a cup with the micro hand, my hand cannot sense anything of the cup; not even that it is actually grasping it. What my hand does sense is the mouse and the mouse button that it presses in order to do the grasping. Thus, what obtains from these interactions is a *uniformity of touch*. Any microworld object that I grasp produces in my hand the same tactile sensation.

Although, as indicated above, a great deal of effort has gone into the Fluent system to provide "fine grained and consistent" interactivity, still, the specific way in which many actions are performed is not congruent with the corresponding actions in the real world. To return to the cup example, grasping and moving a real cup containing liquid is usually achieved by grasping the handle with the fingers, such that the thumb presses down at the upper part of the handle while the other fingers press around the handle. Once the cup is grasped, it can be moved. In the microworld, the corresponding actions are performed by pressing down the mouse button with the index finger, holding it down, and then "dragging" the cup. Another important incongruity is that there is only one microworld hand, such that the help of a second hand cannot be employed when the situation requires it. We can then say that most microworld actions are not congruent with the corresponding actions in the real world.

Let us now focus on the bodily involvement of users with a microworld as a whole. In a real room, where things are located at varying distances from us, to grasp something I walk towards the place where it is located; in the microworld, instead, the computer display brings the entire room close to my body. A simple and minor movement of the hand suffices to visit and grasp any object in the "room," while I remain seated. My bodily position changes minimally; only the hands and eyes (and possibly the head) move, as I have the whole kitchen microworld within the reach of my hand. As a result of this vanishing of distance, together with the disembodied character of the microworld objects and the caesura separating the user's hand from the microworld hand, the bodily involvement that takes place during the user's interaction with the microworld is severely curtailed.

To summarize, due to the disembodied character of the microworld objects the network of relationships that obtains in these worlds is significantly limited; because of the caesura separating the user's hand from the microworld hand the manual involvement with the microworld is impaired; and due to the severe curtailment of the user's bodily involvement with the microworld there is a significant attenuation of the manifoldness of the interaction. We can conclude that, although microworlds have the character of worlds with which users can become engaged, they, nonetheless, are extremely impoverished worlds. This preliminary characterization will be re-examined in a later section from an ontological perspective.

Interactive Capabilities of the Software Tutor:

We now examine certain aspects of the interaction between the user and the "software tutor," focusing on task-oriented interactions, language interactions, and bodily interactions. As stated in FSA (p. 429), the main role of the software tutor is to be "a conversational partner that gradually, realistically immerses the beginning student in the new language." Immersion is achieved by having the student act and "converse" with the tutor in the context of a microworld. On its part, the tutor can perform actions in the microworld, engage in language exchanges with the user, and make tutoring decisions. Dialogues take the form of two or more interactions in which the tutor and the student take turns—to act, ask questions, give comments, and make statements about the microworld (FSB, p. 186). The content of the dialogues in which the tutor engages is determined both by "situation viewpoints" that suggest what to say, and by ways of selecting actions that make sense in a situation (FSB, p. 188). Finally, useful dialogues for language learning can be described in terms of tutorial schemas specifying choices of interaction types, views, and actions (FSB, p. 197).

During interactions, the tutor exhibits several language competencies such as the ability to "interpret" sentences typed by the student, to generate sentences pertinent to the current context, and to initiate language interactions at the appropriate level of difficulty. Thus, in its interactions, the tutor engages in purposive tasks, exhibits reactive capabilities by appropriately responding to interactions initiated by the students, and demonstrates language capabilities that allow it to engage in meaningful language exchanges. In addition, these various capabilities are integrated in a way that provides a useful language learning experience for the student. As a result, the software tutor is endowed with a set of competencies which are constitutive of agency (Russell *et al.*, 1995, p. 31), and it is itself a kind of agent. In effect, purposiveness, reactivity, and communication, all of them at the service of a useful end, are central characteristics of agency.

On the other hand, it is clear that the software tutor has many limitations which detract from its agency. In spite of the variety of mechanisms utilized, its interactive capabilities are limited to "a very short sequence of specified kinds of linguistic and spatial moves" (FSA, p. 442), possibly due to the complexity of managing more extensive dialogues. Thus, in a typical interaction the tutor prints a sentence, the student interprets the sentence as a command and performs appropriate actions, and, finally, the tutor prints a comment on the student action. In consequence, the interactions of which the software tutor is capable are bound to have a deeply fragmentary character, thus affecting its actual and perceived purposiveness.

To enter into meaningful and engaging dialogues, the software tutor should have "knowledge" about the student, including knowledge of his or her general background, interests, and goals. In addition, to maintain a dialogue at the right level of difficulty, the tutor should have information about the student's competence in various aspects of the language. Thus, the need for a "student model" arises. As is well known in the domain of interactive learning environments, the development of adequate student models, and appropriate mechanisms for updating them, is a difficult problem (FSB, p. 191; Sack *et al.*, 1992). In the Fluent system, this problem is addressed both by attempting to minimize the need for such a model and by developing it only up to the level of detail required by the capabilities of the tutor (FSB, p. 191). In consequence, the software tutor "knows" rather little about the student, so that its level of reactivity to the unfolding tutorial situation is seriously compromised and the pertinence of its actions is weakened.

Because of the complexity of natural language, the language processing component of the Fluent system cannot reliably handle students' input (Felshin, 1994). In addition, the content of the language exchanges in which the tutor can participate is totally circumscribed within the narrow confines of microworlds. Finally, the fragmentary character of the user/tutor interactions is also reflected in the language exchanges. In consequence, there is a constant risk that the dialogues will not constitute full language but, rather, that they will be perceived as babble. Such a possibility has been clearly recognized in the design of the Fluent system, which has an elaborate "views" mechanism that allows it to make a variety of meaningful comments on users' actions. As indicated in FSA (p. 449, our emphasis), "besides linguistic variety, the proliferation of views brings with it the possibility for getting language at the right level of difficulty, to avoid useless immersion into perceived *babble*."

With regard to the embodiment of the tutor, although it can perform actions in the microworld, they take place without any visible intervention on its part. In fact, such actions are performed by internal commands describing events affecting specific objects. In addition, the language exchanges which take place in terms of printed sentences displayed in a window, leave the embodiment of the tutor totally undefined. As a consequence, the tutor has a very weak and thoroughly ambiguous embodiment.

Given the limitations we have identified, how can the software tutor as it emerges from its interactions with users be characterized? From one standpoint, the tutor exhibits characteristics typical of agents, such as purposiveness, reactivity, and communications capabilities. From another standpoint, and to a large extent due to intrinsic technological limitations independent of the design of the Fluent system, these characteristics are substantially diminished as evidenced by the fragmentary character of the tutor interactions, their precarious reactivity, the weak pertinence of the dialogues, and their fragile language capabilities. We can then provide a preliminary characterization of the software tutor as a whole as being a quasi-agent, implying that the tutor's agency is compromised in an essential way.

Overall Character of the Learning Situation:

So far we have considered user interactions with microworlds and with the software tutor. But the characteristics of these interactions are co-determined by how the student approaches the learning situation as a whole, which is in turn influenced by the overall character of the learning situation being realized in the learning environment. What are the main principles underlying the learning situation in the Fluent system? First, echoing results from language acquisition research, the Fluent system aims at supporting the learning of language by engaging the student in conversation with a speaker of the language while being immersed in a meaningful situation. Second, this first principle is realized, as stated in FSA (p. 429), "by providing a conversational partner that gradually, realistically immerses the beginning student in the new language," while engaging in conversation about a microworld. In consequence, the overall character of the learning situation is that a partner and a world are provided as computational resources in terms of a software tutor and a microworld, respectively.

Briefly, this character is significant for the following reasons: (i) in the case of microworlds, what is provided is not just an isolated resource, but rather "an entire world"; (ii) in the case of the software tutor the attempt is made at providing not just any kind of resource, but elements of human agency; and (iii) these two kinds of resources are provided as "computational" resources. From the perspective of a user, computational resources have the particularity that they can be brought to life or made to disappear with the push of a button, which confers upon them a peculiar volatility. As a result, the learning situation is constituted by worlds and aspects of human agency that have been made into resources which, by being computational, have an extremely volatile character.

ONTOLOGICAL CHARACTERIZATION OF THE LEARNING ENVIRONMENT

We now attempt to provide an ontological characterization of microworlds and the software tutor; that is, a characterization that aims at the "essential" traits of these elements. As such, this description should account for the phenomena identified in the previous sections, that is, for the significantly impoverished character of the microworlds, for the quasi-agency of the tutor, and for the extremely volatile character of the learning situation.

We begin by considering the deeply ambiguous ontological status of the microworlds. From one standpoint, microworlds are imaginary worlds containing images of familiar things. The cup icon in the microworld is not a real cup; rather, it stands for a cup and, as such, it refers to a real cup, either particular or indeterminate. From another standpoint, microworlds are "real" worlds. We can act in them by performing operations on its objects; we can grasp the microworld cup, move it, and fill it up with water. In this particular sense, the cup icon is no longer an icon but it becomes a real thing. In fact, the microworld objects and the microworld as a whole are computational resources. As such, they acquire a life of their own, achieved by the combination of powerful visual effects and manually-based real-time interactivity.

To account for this peculiar ambiguity of the microworlds, we characterize them ontologically as computationally reified imagery, or reified imagery, for short. Microworlds and their objects are disembodied, as the work of the human imagination, but, because of reification through computational means we can sense them and perform operations with them, as with real objects. Being computational resources, on the other hand, they can be turned off at our discretion, causing whatever shallow level of reality they had to disappear. Such "disappearance" is ontologically quite different from the absence of a thing, because an absent thing is still present somewhere else, while a computational resource can at best be recomputed. This turning on and off at the user's discretion is akin to imagining something, and then letting it fade away.

We can now account for previously identified phenomena. It is because microworlds are computationally reified imagery that microworld objects are shadow-objects, that the actions performed with them are "incongruous," that the bodily involvements users have with them are severely curtailed. This character also accounts for the deep caesura separating the user's hand from the microworld hand. It is the caesura that separates a real world from an imaginary world, precariously bridged by the mouse.

Regarding the software tutor, we cannot examine here its ontological status in detail. Suffice it to refer to the ontological abyss that separates it from human tutors: while human agency grows out of "openness to the world," software-based agency grows out of the execution of rules and procedures in a computing system. For this reason, we characterize them as *closed agents*. It is this ontological character of the tutor that explains such phenomena as its elementary level of purposiveness, low reactivity, and fragmentary interactivity.

With respect to language, if human beings can speak and use language at all, it is because through their openness they are exposed to the other and to themselves; and from such exposure, they can say things in a language (Heidegger, 1962, pp. 203-210). In the closed agent, on the other hand, language does not flow from a fundamental "openness to the world"; rather, it is computed by the execution of rules and procedures specified in a programming language, the only kinds of languages that computing machines can deal with. As a consequence, the language that obtains in the software tutor must be ontologically characterized as a *closed language*. The ever present risk that the tutor's language will be perceived as babble grows out of such ontological constitution.

So far, we have characterized microworlds as computationally reified imagery, the software tutor as a closed agent capable of closed language, and the overall learning situation as a computational resource. Is there a trait underlying these various descriptions, a trait that by characterizing the learning environment as a whole would be determinant for the experience users have with such an environment?

Because in their interactions with microworlds users deal with computationally reified imagery, there is a significant attenuation of the manifoldness of the interaction, such that the visual is over-emphasized at the expense of other dimensions. Visually, the microworld appears very close to us; manually, it remains remote, in the sense that we cannot touch the objects, we can only command them to move. "Grasping" them does not give us much. Being computational resources, these objects have surrendered their independence from us almost completely. Could we continue to say that they are an "other" with which we interact? Yes, insofar as they have the possibility of being computed and assigned to a region of space and time where they will exhibit certain properties. No, insofar as their volatility and our computational power confers upon us users unlimited power to create, destroy, and recreate them.

We can then say that a central ontological characteristic of computationally reified imagery is that its otherness is fundamentally compromised. "Otherness" is understood here in a broad sense to refer to a many-sided character of beings and of our involvement with them, in which they "oppose" us. Briefly, in that opposition, while we can perceive aspects of them as they appear to us, most of what they are remains hidden, even enigmatic. Thus, when we say that the otherness of a shadow-object is seriously compromised, we mean that such an object is mostly what it appears to be for us, and little else. They are hollow beings; they are almost no-thing. With regard to the software tutor, an analysis of its character as closed agent, its ambiguous and weak embodiment, and the other features pertaining to quasi-agency identified in a previous section, would also show a significant attenuation of its otherness.

But there is a final step we need to take in order to obtain a characterization that more fully captures how the learning environment*appears* to users. Let us focus on microworlds. Although it would seem that their precarious otherness should transpire during the interactions, this is not necessarily the case. In fact, computational reification uses a variety of technologies aimed precisely at masking or concealing the disembodied character of the microworld objects, including the hand. Even with the limited reification capabilities offered by today's technology, microworlds seem to be alive. Undoubtedly, we have an awareness that microworlds are not like their real counterparts, but while engaged with them this awareness tends to dilute and it does not appear to interfere with our engagement. Through the reification we experience a micro world, but in such an experience, we do not necessarily seem to realize the notable attenuation of the otherness characteristic of such worlds. This phenomenon, by which the attenuation of the otherness remains concealed, we call ontological masking, or simply masking. In the case of microworlds, perhaps one of the factors contributing to such masking is that although the attenuation of the manifoldness of the interaction obliterates several dimensions of such interaction, it nonetheless preserves many ingredients of the *visual* dimension. Because such a reduction to the visual appears to be a broad cultural phenomenon (see, for example, Ihde, 1973, pp. 23-41), it tends to remain unnoticed, so that the reduction is not experienced.

Masking also takes place in the case of the software tutor, in whose implementation a variety of technologies are used to produce what amounts to a concealment of the closed character of the tutor's agency and language. Other factors may also contribute to such masking, one of which is suggested by Self (1990, p. 4; Self's emphasis): "To understand new concepts we often resort to analogy. The immediate analogy for an ITS [Intelligent Tutoring System] is the only other agent able to perform a similar task, the human teacher. The *ITS as human teacher* analogy pervades the ITS literature - in fact, it is so pervasive that it is difficult to bear in mind that it is only an analogy."

Potential Ontological Effects:

We have suggested that the use of tools influences the way in which the world appears to us. In the case of learning environments, this means that the way microworlds are and how we relate to them will influence the way in which the world appears to us and how we relate to the world in general. To be sure, these complex kinds of influences may take multiple forms and may be realized over multiple, hazardous paths. As such, they are incalculable. What we can do here, then, is to identify a space of possibilities. In addition, we need to note that the influence of these kinds of tools does not operate in a vacuum. Computing technology in general, and learning environments in particular, develop in the much broader context of modern technology. "Resourcification," the making of something into a resource, is taking place in modern technology as a whole (Heidegger, 1977), and learning environments are no exception to this.

We consider the following possibilities. *First*, as we noted in the case of microworlds, because of their disembodied character there was both a significant reduction of experience to those dimensions supported by the underlying technologies, the visual dimension, and a further reduction of the visual experience to the experience of shadow-objects. Such reductions, concealed because of masking, open up the possibility that the excluded dimensions be increasingly "forgotten," so that our ability to experience them in our dealings with the world in general may be substantially impaired.

Second, microworlds were characterized as being computationally reified imagery; in consequence, the microworld objects and the network of relationships that obtain among them are overwhelmingly constituted by human-made elements. We are then dealing with "humanized" worlds from which the other-than-human has been expelled, and end up interacting with "hollow beings" from which "otherness" has almost entirely vanished. If we tend to experience the world in general as we do microworlds, then we could tend to experience it as a hollow complex of relationships, in which only what humans have put in it can be experienced. Although we already dwell in increasingly human-created surroundings, the experience of the world as "other" still remains with us, if significantly attenuated. Will this residual experience survive?

Third, interacting with software tutors, which were characterized as closed agents, amounts to experiencing hollow agency and hollow language. What could the experience of closed language, which because of masking is not necessarily experienced as closed, do to our experience of language as a whole? In interaction with the learning environment we experience a computing machine engaged in language, an event which constitutes a true ontological novelty, as until recently language had not been regarded as possible for machines. Could it become increasingly difficult for us to distinguish between meaningful speech and pure babble?

FINAL REMARKS

We have taken some steps towards determining potential ontological effects generated by the use of computing technology, in particular, interactive learning environments. In the last section we sketched potential effects that could be distilled from the analysis of the main components of the Fluent system—specifically, from its microworlds, software tutor, and their interactive capabilities. We believe that the kinds of interactions identified in the analysis of this system are typical of learning environments in general, and that interactions with microworlds and tutors in environments for learning mathematics, physics, and programming do not differ much from interactions with the Fluent system.

I have certainly not demonstrated that such ontological effects will take place, but I have shown their possibility through plausible argumentation and detailed analysis of a particular learning environment. Much persistent and detailed work remains to be done before we develop a clearer understanding of these potential effects. In our analysis, I did not address the issue of how effective these environments are for supporting learning. Even if the effects we have dealt with here were emphatically shown to take place, this would not necessarily carry weight against the effectiveness of these environments.

Finally, if our analysis indeed captures the ontological novelty of computer-based learning environments, the analysis should, implicitly, show how computing technology fits within modern technology as a whole, as well as its own specificity with respect to it. Heidegger (1977) characterized modern technology as a particular mode of revealing, "Enframing," in which "what is" appears as "standing reserve." Interactive learning environments are precisely an attempt at bringing forth fundamental aspects of a learning situation—namely, a world and a human tutor—as standing-reserve under the guise of microworld and software tutor, respectively. The particular erosion of the otherness exhibited in the ontological characterization of microworlds as computationally reified imagery and of the software tutor as closed agent endowed with closed language, implicitly shows the peculiar way in which computing technology turns "what is" into standing-reserve in terms of computational resources.

REFERENCES

Araya, A. 1995a. "Questioning Ubiquitous Computing." *Proceedings of the 1995 Computer Science Conference*. New York: ACM. Pp. 230-237.

_______. 1995b. "Suggesting Multiple Design Actions Using Prior Cases." *Proceedings of the World Conference on Artificial Intelligence in Education*. Washington, DC. Pp. 373-380.

_______. 1997. "Technological Change and Ontological Transformations: The Case of Virtual Reality." J. Martinez Contreras, R. Gutierrez-Lombardo, and P. Durbin, eds., *Tecnologia, Desarrollo Economico y Sustentabilidad: Proceedings of the Ninth International Conference of the Society for Philosophy and Technology*. Special number of *Ludus Vitalis: Revista de Filosofia de las Ciencias de la Vida*. Pp. 221-239.

Baker, M., and K. Bielczyc. 1995. "Missed Opportunities for Learning in Collaborative Problem-Solving Interactions." *Proceedings of the World Conference on Artificial Intelligence in Education*. Washington, DC. Pp. 210-217.

Borgmann, A. 1984. *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press.

Brown, J., A. Collins, and P. Duguid. 1989. "Situated Cognition and the Culture of Learning." *Educational Researcher*, 18:1:32-42.

Brusilovsky, P., E. Schwarz, and G. Weber. 1996. "A Tool for Developing Adaptive Electronic Textbooks on WWW." *Proceedings of the World Conference of the Web Society*. San Francisco. Pp. 64-69.

Chanier, T. 1994. "Language Learning: Special Issue Introduction." *Journal of Artificial Intelligence in Education*, 5:4:417-428.

Clancey, W. 1993. "Guidon-Manage Revisited: A Socio-Technical Systems Approach." *Journal of Artificial Intelligence in Education*, 4:1:5-34.

Dreyfus, H. 1992. *What Computers Still Can't Do*. Cambridge, MA: MIT Press.

Felshin, S. 1994. "The Athena Language Learning Project NLP System: A Multilingual System for Conversation-Based Language Learning." In M. Holland, J. Kaplan, and M. Sams, eds., *Intelligent Language Tutors: Balancing theory and Technology*. Hillsdale, NJ: Erlbaum. Pp. 257-272.

Fry, T., ed. 1993. *R/U/A TV?: Heidegger and the Televisual*. Sidney: Power Publications.

Hamburger, H. 1994a. "Foreign Language Immersion: Science, Practice, and a System." *Journal of Artificial Intelligence in education*, 5:4:429-450.

_______. 1994b. "Tutorial Tools for Language Learning by Two-Medium Dialogue." In M. Holland, J. Kaplan, and M. Sams, eds., *Intelligent Language Tutors: balancing theory and Technology*. Hillsdale, NJ: Erlbaum. Pp. 183-199.

Heidegger, M. 1962[1927]. *Being and Time*. New York: Harper and Row.

_______. 1973 [1961]. "Metaphysics as History of Being." In M. Heidegger, *The End of Philosophy*. New York: Harper and Row.

_______. 1977 1955]. "The Question concerning Technology." In M. Heidegger, *The Question concerning Technology and Other Essays*. New York: Harper and Row. Pp. 3-35.

Ihde, D. 1973. *Sense and Significance*. Pittsburgh, PA: Duquesne University Press.

_______. 1979. *Technics and Praxis*. Dordrecht: Reidel.

_______. 1983. *Existential Technics*. Albany: State University of New York Press.

Lave, J. 1988. *Cognition in Practice*. Cambridge: Cambridge University Press.

Norman, D. 1993. *Things That Make Us Smart*. Reading, MA: Addison-Wesley.

Russell, S., and P. Norvig. 1995. *Artificial Intelligence: A Modern Approach*. Englewood Cliffs, NJ: Prentice Hall.

Sack, W., E. Soloway, and P. Weingrad. 1992. "Re: Writing Cartesian Student Models." *Journal of Artificial Intelligence in Education*, 3:4:381-399.

Searle, J. 1980. "Minds, Brains, and Programs." *The Behavioral and Brain Sciences*. 3:417-424.

Self, J. 1990. "Theoretical Foundations for Intelligent Tutoring Systems." *Journal of Artificial Intelligence in Education*, 1:4:3-14.

Wenger, E. 1987. *Artificial Intelligence and Tutoring Systems*. San Mateo, CA: Morgan Kaufmann.