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Teaching in 3D: Pedagogical Affordances and Constraints of 3D Virtual Worlds for Synchronous Distance Learning

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ABSTRACT *Three-dimensional (3D) virtual worlds are a new technology that holds some promise as constructivist learning environments for distance education. This investigation presents an evaluative case study of the pedagogical implications of using one 3D virtual world, Active Worlds, for synchronous distance education. The research design for this qualitative study focuses on the pedagogical affordances and constraints. Methods employed in the data collection include participatory observations, class logs, and formal and informal interviews with the instructor of a synchronous distance learning course offered through Active Worlds University. Findings reveal that although Active Worlds provides tools that support constructivist learning environments, the affordances and constraints of the tools (discourse, experiential, and resource) may, to varying degrees, impact the pragmatic use of this medium. While this initial investigation reveals that this technology supports constructivist learning environments, more research needs to be conducted to fully explore the potential of 3D virtual worlds as both distance and traditional classroom learning environments.*

During the past decade, various new and emerging technologies have been designed and adapted as environments for distance learning. Among the more interesting contenders of adapted technologies are three-dimensional (3D) virtual worlds. Three-dimensional virtual worlds can be roughly described as networked, desktop virtual reality. While there are a variety of 3D virtual world applications, typically most provide three important features: the illusion of 3D space, avatars that serve as visual representations of users, and an interactive chat environment for users to communicate with one another. Several of the more popular 3D virtual worlds include Active Worlds, Adobe Atmosphere, and OnLive! Traveler. Although 3D virtual worlds are relatively new, they may afford pedagogical support for fostering constructivist learning environments for geographically distant learners because they provide educators an accessible means of creating a rich and compelling 3D context for situating learning, communicative tools to support discourse and collaboration, and Web integration to provide just-in-time resources and information-seeking tools.

Constructivist Learning Environments

Concurrent with the development of new tools for distance learning has been an epistemological shift in paradigms of learning from an objectivist perspective to a constructivist perspective. Central to a constructivist theoretical perspective is the belief that knowledge is

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constructed, not transmitted, and that learners play an active role in the learning process (Jonassen, 1999). To foster the construction of knowledge, learners should have opportunities for exploration and manipulation within the learning environment (Cognition and Technology Group at Vanderbilt, 1993; Jonassen, 1992). Support for constructivist learning environments should also include discourse opportunities between learners. Conversation and discourse fosters collaboration and supports social negotiation in learning (Jonassen, 1999; Lave & Wenger, 1991; Vygotsky, 1978). This in turn allows learners to share information, test understandings, and reflect on learning (Duffy & Cunningham, 1996; Jonassen, 1999). Additionally, constructivist learning environments should provide models and exemplars to foster the development of problem-solving skills as well as "just-in-time" resources and information gathering tools to enable learners to access relevant and appropriate information quickly (Jonassen, 1999; Jonassen *et al*., 1999).

Virtual Worlds as Constructivist Learning Environments

Despite the fact that relatively little research exists about the use of 3D virtual worlds as distance learning environments, ample research from similar technologies such as immersive virtual reality and multi-user chat worlds indicates that 3D virtual worlds may support constructivist learning opportunities for geographically distant learners (Bricken, 1990, 1991; Bricken & Byrne, 1994; Bruckman, 1997, 1998). Three-dimensional virtual worlds do not offer the full immersive capabilities of virtual reality (VR); however, research from the educational use of VR provides compelling evidence of the potential that graphically rich 3D settings provide for constructivist learning activities (Bricken, 1990, 1991; Bricken & Byrne, 1994; Dede, 1995; Dede *et al*., 1996; Winn 1993, 1997). One of the main advantages of VR is that the learners are able to view an object or setting from multiple perspectives (Bricken, 1990; Dede *et al*., 1996). Dede's (1995) investigations reveal that virtual environments offer many benefits such as opportunities for experimentation without real-world repercussions, opportunities to "learn by doing," and the ability to personalize an environment. Similarly, Bricken and Byrne (1994) noted that VR affords learners opportunities to learn by interacting with virtual objects, which, depending upon content, may lead to better conceptual understanding of the content. This is in part due to the transparent interface that VR affords (Bricken, 1991). Winn (1993) argues that it is this transparency of knowledge representation that allows learners to approach some concepts as first-person non-symbolic experiences, whereas too often information is codified and represented as "third-person symbolic experiences." According to Winn (1993), virtual environments can help bridge the gap between experiential learning and information representation.

Although 3D virtual worlds can be classified as a type of desktop virtual reality, they also provide the communicative and user-extensible functions of text-based virtual world such as Multi-User Domains (MUDs) and MUD Object Oriented (MOOs). Research into text-based MOOs reveals that they too may be used to support constructivist knowledge-building communities (Bruckman, 1997, 1998; Fanderclai, 1995). Findings of Bruckman's research of the text-based virtual world *MOOSE Crossing* reveal evidence of peer role models, role reversal, emotional support, and the presence of an appreciative audience within a community. Riner's findings of research into the educational futuristic role-playing MUD, Solar System

Simulation (SOLSYS), supports many of Bruckman's findings as well as revealing evidence of interactive learning and collaboration across time and space (Riner, 1996).

Three-dimensional virtual worlds also provide components that may further complement or enhance a learning environment. Within most 3D virtual world applications, users may self-select both their identity and their visual representation. Typically, an avatar serves as both the visual representation of a user in the 3D environment and the camera or point-of-view for the user. While there is little empirical research investigating the impact that self-selected identity and representation may have on learning, existing research suggests that it may reduce inhibitions and dissolve social status among users, or reconstruct social status based upon different attributes (Bruckman, 1998; Dede, 1995; Rheingold, 1993).

Despite the considerable interest and speculation about the use of various tools and media for distance learning, relatively few studies have been conducted on the design and implementation of distance learning technologies to support constructivist learning environments, particularly in regards to pedagogy. With the constructivist shift in epistemology, it is important to look for methods of assessing new tools that are consistent with a constructivist perspective. One method of assessment is to consider the *affordances* of a learning environment.

Affordance Theory

The term *affordance* is one that is becoming used increasingly frequently in various fields of design (Norman, 1988, 1993; Ware, 2000). While the term is liberally applied and adapted for the design of computer-meditated environments, the source of this term is grounded in environmental psychology. Visual perception psychologist James Gibson developed "Affordance Theory" to express the relationship that exists between an animal (perceiver) and the environment (perceived) (Gibson, 1977).

To borrow liberally from Gibson, for example, a flat open surface affords locomotion in all directions, whereas a cluttered environment affords motion around objects. Affordance Theory adapted for design might state that a door with a vertical handle affords pulling, whereas a door with no handle and a flat surface affords pushing (Norman, 1988). Central to Affordance Theory is that the relationship between the perceiver (human) and the perceived (environment) constructs the possibility for certain behavior.

Affordance Theory has relevance when examining learning environments. Within a constructivist paradigm, the central focus is shifted from an epistemology of transmission to one of construction. The affordances and constraints of the learning environment impact the opportunities for construction.

Purpose

The purpose of this study is to examine how one 3D virtual world application, Active Worlds™, supports a constructivist learning environment (as suggested in the above) by examining the pedagogical affordances and constraints of (a) the discourse tools; (b) the experiential tools; and (c) the resource tools. The first goal of this study is to illustrate the potential of this medium to support constructivist distance learning environments. The second goal is to investigate the pragmatics of using a 3D virtual world for synchronous distance learning by examining the dynamics involved in teaching with this medium.

Research Design

The methodological framework for this inquiry consists of an evaluative case study. According to Merriam (1998), characteristics of an evaluative case study include descriptions, explanation, and judgement. The purpose for choosing an evaluative framework for this inquiry is not to provide a penultimate judgement about the applicability of 3D virtual worlds for education, but rather to provide thick description and explanation for a better understanding of the pedagogical affordances and constraints of using this visual medium.

The focus of this case study is a 3D object-modeling course, *Intro to RWX Modeling*, offered by and through the 3D virtual world application Active Worlds (AW). This course was chosen because it was presented in a synchronous format and the content of the course relies heavily upon the use of visual information. Due to these factors, it was determined that this course would provide fuller insight into pedagogical affordances and constraints.

Data Sources

Methods employed in data gathering include participatory observations and notes, class logs, screen-captured images, and formal interviews with the instructor in an attempt to provide a “thick description” of the data (Geertz, 1973). Initial data were gathered during the fall of 1998 and winter of 1999. Subsequent observations were conducted during the winter and spring of 2000. Concluding interviews with the instructor were conducted during the winter and spring of 2001.

The Context of the Study

Active Worlds. Active Worlds first premiered in 1995 and is one of the oldest and most active 3D virtual world applications online today. The client–server application consists of the Active Worlds Universe with over 1,000 individual worlds for users to interact with other users worldwide. The AW Universe also affords user-extensible provisions and support for building new worlds and adding to existing worlds. World owners are free to define and customize their world in whichever way they choose by selecting objects from the AW object library or by adding custom-built objects.

Active Worlds browser. The AW browser interface is comprised of four main scalable windows which include a 3D environment, a chat dialogue window, an integrated Web browser, and a window for added navigational and communicational functions (see Fig. 1).

Within the AW environment, users may self-select a unique identity (i.e., alias or nickname). This unique identity may not be used by any other user. A unique identity provides both persistence and accountability. Within a system where users adopt alias identities, a unique identity prevents users from impersonating one another and establishes reliability and consistency in both the personal and social arena.

Within the 3D environment, avatars serve as the visual representation of users currently

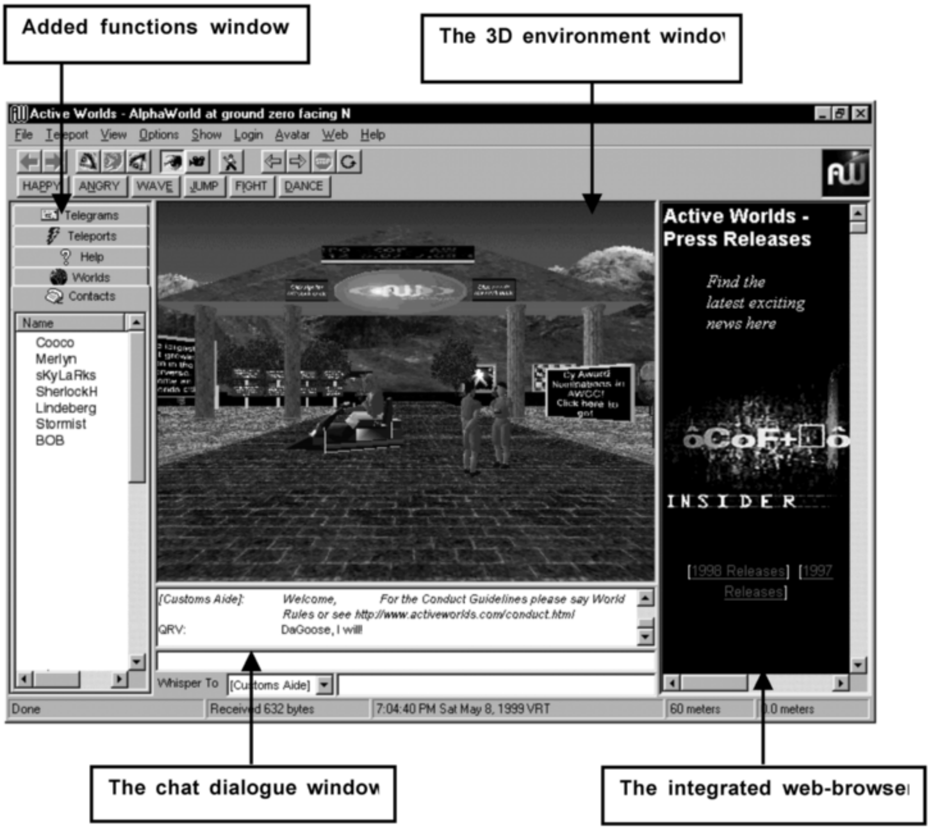

FIG. 1. The Active Worlds browser.

inhabiting a particular world. Users may self-select an avatar from a library of avatars provided in a world setting. A user's unique identity appears above his/her avatar's head. This allows users to identify one another in the 3D environment.

Avatars also serve as the camera or point-of-view (POV) for a first-person perspective of the 3D environment. Users may easily opt to view the 3D environment from either a first-person perspective (through the "eyes" of an avatar) or from a third-person (orthographic) perspective. The third-person perspective allows a user to see his/her avatar within the world setting.

Course context. This investigation centers on a 3D object-modeling course offered by AW University [1] during the fall and winter of 1998–1999 taught by AW user Magine [2]. The course is entitled *Intro to RWX Modeling* [3]. The focus of *Intro to RWX Modeling* is to teach AW users to create original 3D objects. The course consisted of four weekly 90-min meetings.

Class setting and instructor. *Intro to RWX Modeling* was held in the AW University. Within the setting, the instructor had building rights and eminent domain rights that allowed her to alter the setting to suit her needs.

The class instructor, Magine, was the creator of *Intro to RWX Modeling*. Although she is an experienced programmer, she has no formal training in 3D modeling, nor has she any training as a teacher.

Data Analysis

Data analysis consisted of a comprehensive review of class logs, notes, instructor interviews, and images gathered during the duration of the course. Categories were liberally derived based on Huberman and Miles' (1994) variable-oriented and pattern-clarification strategies for identifying themes and patterns. Class logs were encoded two ways. The first coding consisted of teaching methods employed such as presenting concepts, exemplification, and confirmation checks. The second encoding also relied heavily upon class logs; however, dialogue was encoded to look for patterns of various tool use. After encoding revealed patterns of teaching methods and tool use, the course instructor, Magine, consented to additional follow-up interviews focusing on pedagogical issues pertaining to the various tools.

Findings

The Discourse Tools

Within the AW environment, the primary means of communication is with the chat tool. The chat tool is located beneath the 3D environment.

Affordances. Magine used the chat tool as the primary means for course content discussions. In each class meeting, she presented a concept for discussion by using the chat tool. To foster understanding of the concept, she used a combination of the chat tool, the 3D environment, and resources located in the integrated Web browser for further illustration and explanation. Learners were encouraged to interact with each other, and with the environment. The advantage of having a synchronous chat tool is that it affords learners immediate feedback and interaction. The following excerpt is from a class in which Magine began presenting the concept of polygons, but quickly determined that her learners needed preliminary information about vertices. She quickly changed her strategies and instead began presenting the concept of vertices and how they define an object in three-dimensional space:

1. Magine: but let's back up a second, because I wanted to explain about vertices …
2. Builder M: so if you just add quad 1 2 3 4 *drifts off thinking* *smirks*
3. Nieves: Where do you list them?
4. Magine: nieves, I will get to that, I want to explain the abstract concepts first :)
5. Nieves: ok
6. Magine: so … a vertex is described in terms of it's position in 3d space, using 3 numbers
7. Magine: called x, y and z
8. Magine: as you see on this model here with the arrows

In line 8, Magine is referring to an object she created that depicts axis (see Fig. 2). She uses this object as a visual illustration of how vertices are defined in 3D space. During this time, several students were observed moving their avatars around the axis object. Because they kept

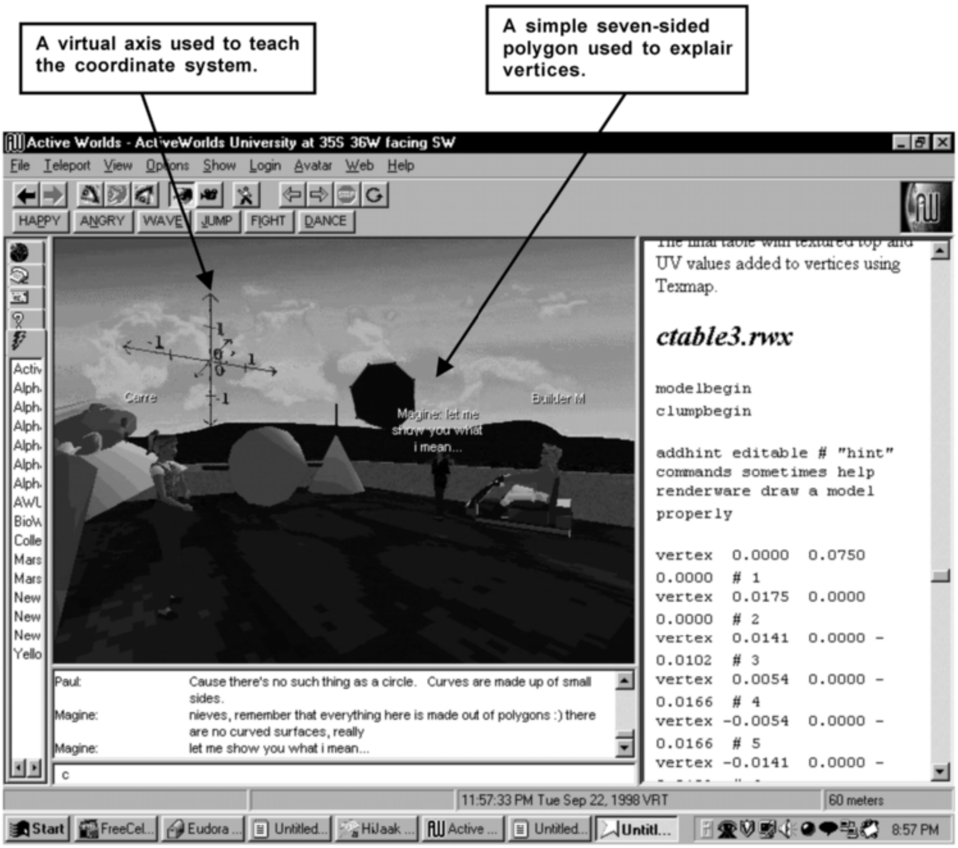

FIG. 2. The virtual axis and a simple seven-sided polygon.

their avatars facing the axis, it was assumed that they were exploring the axis from different perspectives.

9. Magine: to create a polygon like this,
10. Magine: you would first describe each vertex by listing it's x, y and z coordinates

In lines 9 through 10, Magine refers to a simple polygon with seven small red balls used to illustrate the vertices (see Fig. 2).

In addition to using the chat tool to discuss concepts, she also used it to instruct students where to look to find examples, as well as for confirmation checks. She often referred to objects placed in the 3D environments that illustrated a particular concept, or she directed students' attention to a resource or example:

12. Magine: if you open your web window and click on that blue sign over there, you can see an example
13. Magine: everyone got it?
14. Paul: yes
15. Nieves: looking
16. Builder M: yes

In line 12, she instructs students to click on a blue sign located within the 3D environment. Clicking the sign activates each student's integrated Web browser to load resource information. In this case, the Web page consisted of the scripts (coding) for several 3D objects (see Example 1). In addition to using the chat tool to direct attention, she also used the tool to seek confirmation from her learners.

Throughout this investigation, there was evidence of social negotiation in which learners would appear to use the chat tool as a forum for self-talk. They would paraphrase information to verify with Magine and the other learners whether they were correct in their understandings. Often this paraphrasing or restating information would take the form of a statement with a question mark at the end in what appeared to be an attempt to check understandings.

Learners were also observed to peer-mentor other learners. This occurred on many levels. Learners arriving late to a class often asked Magine questions about what they missed. Rather than interrupt Magine's flow, learners who had attended class regularly would answer. Additionally, learners would offer short explanations and advise other learners about techniques and strategies both during classes and during homework reviews.

Constraints. As some of the passages above reveal, the AW chat tool affords opportunities for synchronous distance learning. Magine successfully presented new concepts for discussion, fostered interaction and explanations, and received confirmation of understandings through the chat tool. Because interaction and feedback was immediate, she could alter her instruction to be responsive to student needs. While the affordance of synchronous discourse tools provided opportunities for immediate exchanges and interactions, subsequent interviews with Magine revealed that there were constraints she had to manage.

Because the AW chat tools permits only 255 characters, Magine had to divide her presentation into many separate messages. While this may seem analogous to breathing or taking a pause in face-to-face conversation, it is important to note that messages must first be sent to a central server and then dispersed to many other users. This type of pause is one in which the speaker may have little control over pacing. As a strategy, Magine relied upon an outline to keep focused on the task. Despite the constraint over pacing, she did not consider it problematic. According to Magine, the chat tool afforded her the possibility of conducting several conversations simultaneously. While some educators might find this difficult to manage, Magine considered this an asset. Moreover, according to Magine, the delays in response time permitted, and even encouraged, thoughtful replies.

Unique identities: affordances. Within the AW environment, users are usually distinguished by their unique identities. Each user is granted a unique name that no other user may use. This affords learners a consistent, identity. In an environment where learners may self-select identities, unique identities help maintain anonymity, but with consistency and accountability.

Unique identities also afford instructors and students a degree of control over the learning environment. Users may opt to *mute* another user within the environment. *Muting* a user will stop messages from the muted user from appearing in the chat tool of the person activating the *mute* command. However, muting a user will not prevent messages from the muted user from appearing in any other user's chat dialogue box. In the case of Magine's class, one student was consistently disruptive and she chose to deal with the situation by publicly threatening to mute him. As the passage reveals, she publicly stated to the class and the troublesome student that she had opted to mute a particular student and thereby would no longer be able to read messages from this student:

> Magine: BM i have muted you, so i wont be able to respond to anything else you have to say
> Magine: i suggest anyone else who is distracted do the same

Constraints. Due to the type of font used in the chat tool, users have found ways to appear as another user. An interesting case surfaced during one of Magine's classes. At the beginning of one class, there appeared to be several pairs of students with the same names. One user in each pair seemed to be very disruptive, while the other user of each pair seemed consistent with previously displayed behavior. The following is an excerpt of that class meeting as it appeared:

61.	Cloud:whats a texmap?
62. Builder M:	*Becomes silent*
63. Builder M:	*Chews gum*
64. Paul:	It's a map of texas
65. Cloud:	Cool
66. Cloud:	heheh..lol
67. Paul:	Very funny, Paul
68. Paul:	yes
69. Builder M:	Where is BM?
70. Builder M:	The other me
71. Builder M:	Fill me in on what i missed
72. Paul:	No
73. Paul:	I don't want to
74. Paul:	:p
75. Builder M:	ahhhhhhhhhhhh brb
76. Paul:	How can someone be using my name?
77. Paul:	Good question =)

In lines 69 and 70 one user (Builder M) recognizes that there is another user who appears to be using his/her name. In line 76 Paul also questions how someone could be using his name. The sans serif font type used in the AW chat tool caused this confusion. The previous dialogue (lines 61–77) displayed with a serif font revealed that there were not three sets of students with the same names, but rather several users exploiting the fact that the sans serif font did not make it possible for users to easily distinguish between a lowercase l and an uppercase I. The previous dialogue read with a serif font reveals that there were one or more users posing as other students by using similar names (Cloud and CIoud, Paul and PauI, and Builder M and BuiIder M).

Findings: Experiential Tools

Within a constructivist learning environment, experiential tools may take many forms such as cognitive tools, knowledge-modeling tools, and performance tools (Jonassen, 1999). In a 3D virtual world environment this list must be further expanded to include the affordances of tools that represent the learner in the learning environment. Because virtual world settings are simulated environments, to some extent, learners must rely upon the affordances of user representation (avatars) within the environment.

Avatars: Affordances and Constraints.

Within an AW environment, users are represented as an avatar. World owners may select avatars from a pre-existing library of avatars or create their own selection for users to use in a particular setting. The result of having to choose from a selection is that many users may be using the same avatar. Because of this limitation, it is usually impossible to recognize another user based on appearances; rather, users must rely on a unique identity.

Because Magine had special privileges assigned by the AW University owners, she used an avatar that was a slightly modified version of a standard AW avatar. Her modification was based on personal preference rather than an effort to stand out from the other users in the environment. However, a small modification of color did help distinguish her within the setting, making it easier to identify her.

Point-of-View and Kinesthetics

Affordances. Avatars serve not only as the visual representation of users in the 3D environment, but they also serve as the camera or point-of-view (POV) for a user. Users can look up and down, and side to side. Additionally, avatars can move forward and backwards; side to side (slide); and up and down (fly).

During each class, learners were frequently viewed moving around objects to examine them from multiple perspectives. In the following excerpt [4], Magine is illustrating the concepts of ambient, diffuse, and specular lighting. Within the 3D environment she had loaded nine spheres to illustrate the range of each lighting sample (see Fig. 3):

1. Magine: these spheres (rw-amb1.rwx) show how the ambient command affects an object
2. Magine: the next lighting command is “diffuse“
3. Magine: it determines how light reflects off an object, in a diffuse or fuzzy way :)
4. Magine: finally, there is “specular”,
5. Magine: which determines how light reflects off the object in a specular or mirror-like way
6. Magine: here, i’ll put all 3 sets over here to compare …
7. Paul: You have to view them from the other side to see the effects
8. Magine: hm, maybe they’d look better on the other side, so you can see the sunlit side:)
9. Nieves: Ambient is the only one a see a variance in
10. Magine: well, nieves, do you notice that there is a highlight on the ones with a high specular value?
11. Magine: jak, the top row, rightmost sphere would be “ambient 1“
12. Magine: middle row, rightmost is “diffuse 1“
13. Magine: bottom row, rightmost is “specular 1” Jakknife: thx;)

During her explanation, learners were observed to be moving around the objects, as evidenced

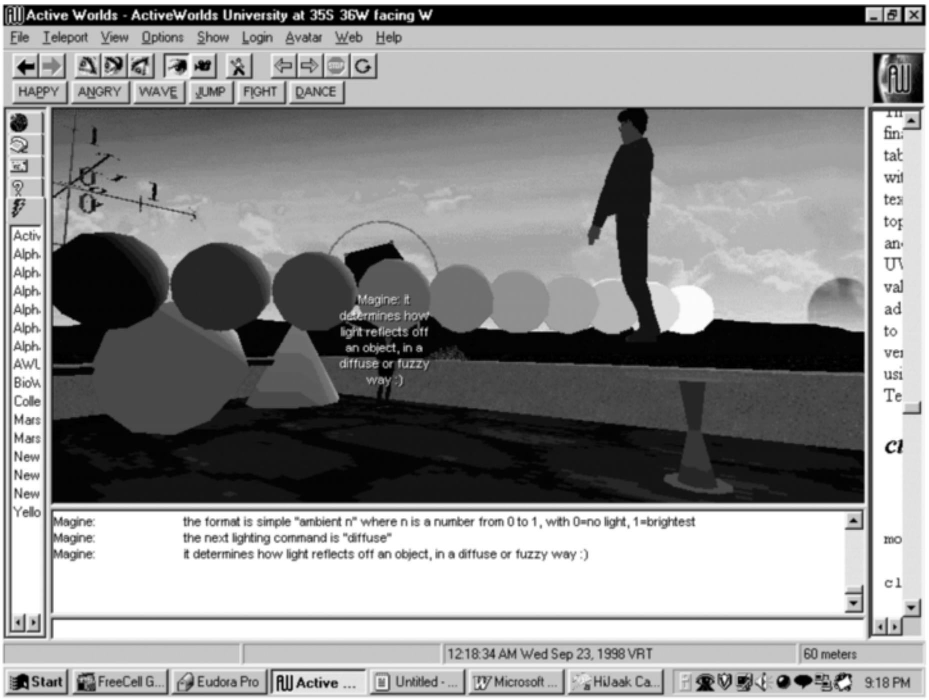

FIG. 3. Nine spheres used to illustrate various lighting commands.

in Paul's suggestion (line 7) to move to the other side of the objects to see the effects Magine is describing (line 8).

Constraints. While kinesthetic constraints did not directly interfere with Magine's teaching, it was something she had to circumvent when teaching. Avatar movement is limited. At this time there are no provisions for a user to control individual limbs of her/his avatar. If Magine needed to direct attention to an object, she could not control her avatar to point to it, but instead had to rely on using the chat tool to describe an object or convey her instructions. While Magine successfully used the chat tool to circumvent kinesthetic limitations, in an interview she expressed the desire to be able to gesture or draw diagrams within the learning environment.

Knowledge-Construction: Affordances and Constraints

Within a constructivist learning environment, learners should have opportunities for exploration and manipulation to foster the construction of new knowledge. While Magine attempted to provide opportunities, the constraints of the AW environment required circumvention. At the end of each class, Magine assigned homework for her learners. Typically, homework consisted of creating an object that illustrated some of the concepts and procedures covered during class. However, learners did not have access permission to upload their objects into the 3D environment, so they had to e-mail their object files to Magine. Toward the end of each class meeting, Magine loaded student homework into the 3D environment. By use of the chat tool, a friendly critique ensued as learners provided feedback about each other's objects. Having the opportunity for learners to display their work and discuss it within a forum of their peers afforded opportunities for group problem solving and role reversal as learners explained techniques and strategies to peers. Despite the affordances of the chat tool, there were logistical constraints. Because learners were not permitted to upload objects into the 3D environment, they could not view their work until the following class when Magine uploaded their files. The lack of provisions for sending and receiving files within the AW environment forced learners to rely on outside tools. In order to view objects prior to class, learners had to rely on an external RWX viewer application. While the learners were able to view objects prior to class, the RWX viewer application did not provide full context of how the object would appear in a world setting. Additionally, learners had to rely on external e-mail applications to send object files. In turn, the burden of receiving e-mail and at times cleaning up object files in order to load them into the 3D environment rested upon Magine and not on the learner.

As previously noted, Magine revealed the desire for integrated tools or provision which would allow her to draw diagrams within the environment. While the chat tool allowed learners to engage in dialogue, there were no tools or provisions which allowed them to work collaboratively on creating objects. Learners created objects individually and had to rely on external tools and Magine rather than being able to create objects within the learning environment. The lack of provisions such as an integrated whiteboard, collaborative writing space, and access to the server imposed constraints that limited collaborative activities.

Findings: The Resource Tools

Within the AW browser, users may select to display the integrated Web browser. The integrated Web browser is displayed on the right side of the browser window. Within the 3D environment, sensors may be placed in an object or location. When a sensor is encountered by a user, it triggers a pre-specified Web page to load in the integrated Web browser. Because the Web browser by default takes up approximately one-third of the AW browser, some world owners opt to design Web pages that will fit within small horizontal dimensions.

Affordances. Magine used the integrated Web browser very effectively for exemplification of concepts. Within the 3D environment, she had placed a sensor that allowed students to click on a sign to activate their integrated Web browser to load pre-specified Web pages and often referred to information contained within the Web pages for further exemplification. In the following example, Magine refers to a particular script (rw-cone3.rwx), thereby enabling learners to view both the underlying script (illustrated on the Web page) and the 3D object that results from the script (in the 3D environment).

> Magine: if you skip down the web page to rw-cone3.rwx, you can see how i've numbered the vertex lines
> Nieves: so basically this is creating an object is like writing a short program?
> Magine: exactly, yes
> Magine: each line in the rwx script is an instruction that you're giving renderware :)

Magine also used the integrated Web browser to refer learners to resource Web sites. Prior to the first class meeting, she sent e-mail messages to each learner with a list of resource Web sites that contained supplemental materials. Throughout her class, she occasionally referred to those Web sites.

Constraints. While the Web browser may be resized, most of Magine's material was sized to fit the narrow default width which allowed students to view the 3D environment as well as the underlying scripts for those objects. There were relatively few restraints with the integrated Web browser; however, to avoid delays, Magine was mindful of the file sizes of her Web pages.

Discussion and Implications for Further Research

The purpose of this investigation was to examine how one 3D virtual world application, Active Worlds, supports a constructivist learning environment by examining the pedagogical affordances and constraints of the discourse, experiential, and resource tools. The goals of this investigation were to illustrate the potential and to examine the pragmatic use of this medium as a constructivist learning environment for distance education. The findings of this investigation revealed that the discourse, experiential, and resource tools support a constructivist learning environment; however, constraints of the discourse and experiential tools may impact the pragmatics of using this medium.

Through examination of the class logs and interviews with the instructor, Magine, the findings of this investigation revealed that there are provisions in AW that can support a constructivist learning environment for geographically distant learners. The primary means of instruction relied heavily upon the use of the discourse tools. Evidence revealed in this investigation is consistent with many of the findings of Bruckman's (1997) and Riner's (1996) research of text-based virtual worlds. The discourse tools of AW afforded immediate peer support and role reversal. Learners often came to each other's aid with explanations and clarification. Evidence also revealed the presence of an appreciative audience, collaboration with social negotiation, and peer mentoring among learners.

While the discourse tool afforded opportunities for meaningful discourse, this investigation further revealed constraints that required circumvention. There were problems with the font type, which allowed users to circumvent limitations of unique identities. There were also no provisions for turn-taking or threaded discussion. Although neither the students nor the instructor indicated that these constraints impeded learning, the participants in this study were experienced users of AW and well acclimated to the constraints of the discourse tool. Also revealed in this investigation were limitations of the length of messages users could post at one time. While the instructor of this course did not feel it imposed greatly on her ability to communicate, for novice users, the constraints of the discourse tool may diminish both the effectiveness and pragmatics of using this medium.

Active Worlds, as a type of desktop virtual reality, may not afford the multi-sensory experiences of immersive VR; however, evidence revealed in this investigation is consistent with Bricken's (1990) and Dede *et al.*'s (1996) respective findings of the benefit of multiple perspectives. Learners were frequently observed moving their avatars around objects for viewing. Dialogue confirmed that learners benefited by the affordances of multiple perspectives. Evidence presented in this investigation also supports studies of VR in which the intuitive interface affords learners a sense of presence in the environments. Dialogue such as one learner instructing others where to move for a better vantage of lighting samples, indicates that learners felt to some degree a presence in the AW environment. While the AW interface does not afford the same degree of transparency as immersive VR, there is evidence of learners interacting with objects and other learners in the 3D environment.

While many of the affordances of the experiential tool indicate that AW offers some promise, there were limitations and constraints that require further consideration. There was a lack of affordances to support collaborative activities such as a whiteboard and a collaborative writing space. Additionally, students did not have access to the server for uploading projects into the 3D environment. Providing access to the server could be easily controlled by a world owner. It is also possible that the integrated Web browser might be a possible avenue for collaborative activities. The ability to launch and resize a second Web-browsing window would allow educators to use Web-based whiteboards and collaborative writing tools; however, an over-reliance on web-based resources might tend to diminish the role of the 3D environment.

While some of the findings of this investigation seem promising, it is important to note that this investigation was limited to a course offered by Active Worlds for Active Worlds users. The learners were already familiar with the technology, codes, and customs of the learning environment. As evidenced in several of the excerpts of class dialogue, there were no provisions for turn-taking. The kinesthetic constraints do not allow for actions such as hand-raising. Typical rules of conduct have to be redefined. Additionally, Magine is an experienced programmer and AW designer. While her teaching experience is limited, she has advanced technical and computing skills beyond those of a novice user. These factors undoubtedly influenced the nature of her classes. She was experienced with the codes and customs of an AW user, and she possesses the technical expertise to adapt her setting, and to adapt to problems that might occur in the setting.

The scope of this qualitative case study is by no means comprehensive, but rather intended to examine how the discourse, experiential, and resource tools of one 3D virtual world support a constructivist learning environment for geographically distant learners. The focus of this investigation is on the pedagogical implications of the affordances and constraints of these tools and not on effective means for using them. The findings of this study are not a prescription of how a distance learning course using this medium should be structured, nor do they explain how a learner might interact with these tools. Rather, the findings of this study reveal some of the advantages and limitations an educator might encounter by using this visual medium for synchronous distance learning. The applicability of these findings for researchers and practitioners can only be determined based on the context in which this 3D virtual world might be used for further research and practice.

It is important to acknowledge that the tools do not evoke the dynamics of a learning community, but rather these dynamics are the result of the interplay between content, the instructor, and the learners. However, the affordances of tools may influence opportunities for discourse and interaction. Three-dimensional virtual worlds are an emerging technology and do not as yet offer the immersive, interactive, and experiential opportunities of VR. They do, however, afford multi-user discourse options for geographically distant learners. While this investigation reveals many of the constraints that the Active Worlds 3D virtual world application poses for distance learning, further development of both the discourse tools and the experiential tools would likely enhance and expand the effectiveness of this environment as a medium for distance learning.

This present study proposes that 3D virtual worlds may be an effective medium for distance learning, depending upon context and resources available; however, more research needs to be conducted to explore the potential fully. This study was limited to the pedagogical affordances and constraints of this medium in a synchronous distance learning environment; however, further research should be conducted into learner perspectives of this medium. Because this medium relies heavily upon the use of discourse tools, a discourse analysis of class logs would likely yield information about the dynamics of learner interaction patterns. Additionally, a study using a think-aloud protocol might yield information about the interface and the interaction between the discourse, experiential, and resource tools. In addition, there is a need to further examine the conceptual framework of learners in this environment to determine ways in which these tools might be used most effectively. Further detailed investigations of these dynamic environments may provide researchers with a better understanding of how learners interact with each other and their learning environment.

NOTES

[1] Active Worlds University is the name of a world created solely for the purposes of providing ongoing education for AW users.
[2] Magine prefers to be referred to by her AW identity.
[3] The AW browser uses RenderWare (RW) to render the 3D scenes (worlds). The Active World browser relies on RenderWare scripts (RWX files) to define the objects in the 3D setting.
[4] Some dialogue has been omitted from this excerpt.

Example 1. Rw-poly2.rwx: A simple polygon composed of seven vertices

```
modelbegin
clumpbegin
addhint editable
vertex 0.0950 0.0689 −0.0000
vertex 0.0574 0.1242 −0.0552
vertex −0.0272 0.1379 −0.0689
vertex −0.0950 0.0996 −0.0306
vertex −0.0950 0.0382 0.0306
vertex −0.0271 0.0000 0.0689
vertex 0.0574 0.0136 0.0552
color 0 1.5
surface.4.3 0
polygon 7 1 2 3 4 5 6 7
clumpend
modelend
```

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