Toward a Desktop System for Effective Computer-Aided Language Learning

Zopito A. Marini
John O. Mitterer
Alan R. Powell

Abstract: To be an effective instructional option. Computer Aided Language Learning (CALL) environments must offer the learner more realistic instructional experiences. To do so, these environments must involve more than dynamic interactivity, a well-known capability of computer-based technologies; they must also offer multiple media, including text, graphics, and sound, as well as more natural interactions, to allow the learner easier and more intuitive access to the environment. In addition, the CALL systems used to design these environments must themselves become easier for language instructors to acquire and master. Such systems must include hypermedia capabilities, direct manipulation interfaces, and a large storage capacity, such as a Compact Disc-Read Only Memory (CD-ROM). A "desktop" system with these capabilities can now be constructed from inexpensive "off-the-shelf" components. The use of such a desktop system is illustrated by describing the development of Around the House, a CALL environment designed at the Brock University Hypermedia Laboratory.

Résumé: Pour être une option d'enseignement efficace les environnements de *Computer Aided Language Learning (CALL)* doivent offrir au débutant des situations d'enseignement plus réalisties. Pour cela, environements doivent proposer plus qu'une interactivité dynamique; ils doivent aussi offrir un média multiple, comprennant les textes, les graphiques, le son, et les interactions naturelles pour permettre ainsi au débutant un accès plus facile et plus intuitif à l'environnement. En plus, les systèmes CALL devraient faciliter la connaissance et l'acquisition pour les professeurs de langues. Ces systèmes devraient inclure les capacités des hypermedia, les interfaces de manoeuvre directe, et une très vaste capacité de rangement, tel que le *compact disc-Read Only Memory CD-ROM).* Avec ces moyens, un système en éditique peut être construit a partir d'une composante "off the shelf." L'utilisation d'un système en éditique est illustrée par la description du développement de *Around the House*, un environnement de CALL conçu au laboratoire hypermedia a l'Université de Brock.

Total immersion, preferably in a living linguistic community, is the best way to learn a language (e.g., Apelt, 1981; Ng & Olivier, 1987; Jones, 1983). Although this ideal is not always achievable, it nevertheless defines the goal for language instruction. Thus, an "effective" technology-based language learning environment must offer some degree of useful approximation to "real-life" situations (Mitterer, Marini, MacRae & Joe, 1989; Mitterer, MacRae & Marini, 1988). At the same time technology must reduce the instructional burden on the language teacher (Higgins, 1985, 1986). There will be no revolution in CALL unless technology is grounded in the broader context of understanding how to construct effective language learning environments and is made easier to use.

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One obvious dimension of the real-life situation is interactivity; effective language learning does not involve a mere passive reaction to presented material. The difficulty of creating fluid real-time interaction prevented older technologies, such as the tape-recorder, from gaining wide acceptance (Hannafin, 1989; Schwier, 1987, 1989). Similarly, the possibility of designing instruction that allows greater interactivity is what attracts language instructors to computer technology.

The first goal of this paper is to go beyond the issue of interactivity to discuss two other dimensions which CALL environments should offer the learner who *seeks* effective *language learning* experiences. The first, multiple media, involves the integration of various media, including at least text, graphics, and sound, into language learning environments. The second, natural interaction, allows for a better relation between the learner and the CALL environment.

The second goal of this paper is to describe a "desktop" system which enables the *language instructor* to create effective learning environments, and which is relatively inexpensive and easy to use as well. Such a system can be constructed from widely available, "off-the-shelf" components and defines a new minimal capability for CALL systems. This capability includes a direct manipulation interface (to make it easier and more natural for instructors to design environments), hypermedia tools (to allow the easy incorporation of multiple media in environments), and a large storage capacity such as CD-ROM (to store the large amount of information contained in the resulting environments). A desktop CALL system such as the one outlined here makes it possible for more language instructors than ever before to design effective interactive, multiple media instructional environments.

The final goal of this paper is to provide a case study report of the performance of the type of desktop CALL system outlined here by describing the production of a demonstration CD-ROM (called *Around the House)* at the Brock University Hypermedia Laboratory.

APPLYING TECHNOLOGY IN THE SERVICE OF LANGUAGE LEARNING AND LANGUAGE TEACHING

While the primary focus of this paper is not on the theoretical issues involved in designing effective language learning environments, it must be stressed that these issues can not be ignored. The broader context within which this paper can be situated is the idea that the design of effective language learning environments can be treated as a problem-solving exercise or a search through a "design space" of possibilities (Pirolli Greeno, 1988). The difficulty in creating effective language learning environments stems both from the fact that the field of language learning and teaching is very broad and complex, and the fact that the types of material which a teacher designs will depend on a large number of factors (Reigeluth, 1983; Gagne, 1987), such as the level of

language skill being learned (e.g., phonetic, lexical, or semantic), the expressive mode being used (reading, writing, listening, or speaking), and the matter of whether one is learning a first or second language (Smith, 1987).

Ideally, an appreciation for the design space of CALL environments requires a consideration of issues involving at least four different types of knowledge, or theoretical framework. First, a knowledge of instructional design (e.g., Gagne, 1987; Reigeluth, 1983) sometimes provides the broadest framework within which more detailed types of knowledge are situated. Second, knowledge of language learning must be considered in view of advances in learning and developmental theories (Anderson, 1982; Case, 1985, in press; Fischer, 1980; Pascual-Leone, 1970) have made valuable contributions to the evolution of instructional design (e.g., Case & Bereiter, 1984). Third, knowledge of language teaching must also be considered. While it has long been assumed that a good psychological theory of learning could be translated into a useful theory of teaching, it has now become evident that the two types of theory cannot be easily transposed (Strauss, 1986). At best, advances in cognitive learning theories have begun to provide an anchoring point to be considered while developing instructional designs (see Bonner, 1988) and have made modest contributions to the development of theories of teaching (e.g., Gagne, 1963, 1968). Finally, for those interested in CALL, knowledge of the applicability of computer technology must be considered (Mitterer, Marini, MacRae & Joe, 1989).

It is important to note that knowledge of instructional design, language teaching, *and* language learning provide the theoretical context within which the applicability of computer technology, the primary focus of the current paper, must be situated. In other words, it is important to integrate knowledge of the applicability of technological systems with the other sources of knowledge mentioned above. This integration is far from complete, as much more theoretical work is required in all of these areas. Because of the complexity of the issues involved, it is tempting to seek to deploy computer technology in language learning without attempting any integration. This would be a mistake; ignoring the complexity of the issues, which can only be addressed within the broader framework mentioned above, leaves the use of computer technology ungrounded and might well lead to a repetition of the audio lab situation of twenty years ago (Clark, 1983; Clark Snow, 1975; Mitterer, 1989).

Dimensions of Effective Language Learning Environments

In terms of the framework articulated above, the design space of CALL must be searched to find effective learning environments. This involves going beyond the recognition that interactivity is a key dimension of such environments; accordingly, two additional dimensions are proposed: multiple media and natural interaction.

The first, multiple media, refers to the fact that real-life language learning normally involves a total sensory experience, including hearing others speak,

reading what they have written, and seeing what it is they have described. Thus, language instruction should aim at integrating a variety of media, in order to approximate the real world in the classroom; the more effectively different media can be integrated into a single environment, the more readily instruction should be conveyed to learners. At a minimum, CALL environments should include the media of text, graphics, and sound.

The second, natural interaction, refers to the fact that another feature of real-life language learning is the naturalness or ease with which the language learner can interact with the environment. In contrast, many CALL environments present difficulties in this regard, requiring a keyboard or other awkward ways of communicating with the computer. Clearly, new technologies will be required to make input to and output from CALL environments more natural. At a minimum, CALL environments should support "real world" operations like picking up and moving objects, pushing buttons, opening file folders, and so forth.

A "DESKTOP" SYSTEM FOR CALL

"Desktop" is a computer industry term which describes once-advanced and expensive technologies that have been brought within the reach of the "average" user. For instance, "desktop publishing" has brought the capabilities once available only to professional publishers within the reach of most people with a personal computer. By extension, "desktop CALL" can bring the ability to design relatively effective language learning environments to most language instructors, A "desktop" system for CALL, offering a new minimal capability must include, 1) a direct manipulation interface; 2) hypermedia; and 3) the use of CD-ROM technology to store the large amounts of information required to design effective instruction.

1) *Direct-Manipulation Interfaces:* Direct manipulation interfaces have come into widespread use because they are easier and more natural ways to interact with computers than were earlier interfaces. While direct manipulation interfaces clearly still do not allow fully natural interactions, they represent a major step in the right direction. These interfaces are important not only because they make it easier for learners to use CALL environments; they also make it easier for instructors to design more effective environments. While instructional goals should be of paramount importance, the reality of the resource limitations which language instructors often have to deal with cannot be ignored. Unless computer technology is easy to use and makes only moderate demands on time, it will, like its predecessor, the audio lab, be ignored by a large number of language instructors (see Clark, 1983; Clark & 'Snow, 1975).

The most widespread example of a direct manipulation interface is the one used in which is based on graphical representations such as icons and pull-down menus, as well as a mouse, to manoeuvre about the

computer. The fundamental operations of this interface mimic "real world" actions like picking up and moving objects, pushing buttons, opening tile folders, and so forth. Comparable interfaces are available for IBM (e.g., OS/2) and MS-DOS (e.g., Microsoft Windows V3.0) as well.

2) Hypermedia: Hypermedia is a new model of how to store and search large volumes of information combining multiple media (e.g., Conklin, 1987). New advances in digital technology allow the integration of vastly different media, such as text, graphics (including computer-generatedstill graphicsand animated sequences, as well as digitized still photographs, video, and film), and sound (including computer-generated synthetic music and speech, as well as digitized music, and human speech). While it is beyond the scope of the current paper, the integration of analog media such as videotape and videodisc-based materials is also possible.

The point of interacting with such an environment (or "hyperdocument") is often not simply to search for one or more pieces of information. Bather, it is to develop an overall appreciation of the organizational structure of the environment. Different pieces (or "nodes") of a hyperdocument are related ("linked") together as the designer of the environment wishes. The process of following links from node to node in an environment is called navigating (Conklin, 1987). In a rich environment (one with many interlinked nodes), two different readers may navigate in very different ways, depending upon each reader's predilection. Even the same reader may navigate an environment in different ways on different "readings". By reading through such an electronic environment in a variety of ways, the reader can explore independently, move into previously unknown areas, and come to appreciate the structure of the underlying set of ideas which that environment represents.

As a hypothetical example, consider learning German through an environment concerning the life and times of the poet Schiller. The "reader" of the environment may choose to follow a link which leads to the German text of one or more of Schiller's poems. Other links might lead to cross-indexed English translations or bring up a voice reading a selected verse in German. Another link might simultaneously call up the music from Beethoven's Ninth Symphony, which incorporates an adaptation of Schiller's *Ode to Joy.* Still other links may lead to illustrations of the area of Germany where Schiller lived, to essays (in German) on the political and cultural context within which he wrote his poems, to the poetry of related poets, and so forth. In short, hypermedia allows the expression of a virtually unlimited range of instructional options.

The best-known example of a hypermedia system is Apple's HyperCard. A number of other systems are currently available, including Guide, Plus, InterMedia, and SuperCard for the Macintosh and Guide, HyperTIES, ToolBook, and Plus for the MS-DOS world. Because these hypermedia systems can be operated through direct manipulation interfaces, they make it relatively easy to create environments, and to add digitized sound and scanned graphics without requiring extensive programming experience.

3) Large Storage Capacity via CD-ROM: Unfortunately direct-manipulation interfaces and hypermedia systems can be memory intensive. Although small hypermedia environments can be produced using conventional computer memory technology, more extensive use of graphics and sound does require more computer memory. One minute of digitized sound can easily require 1.3 megabytes of storage, and one digitized colour image can require more than 1 megabyte of storage. It is no longer unusual for an environment to contain 100 or more megabytes of text, graphics, and sound, which would take about 60-120 diskettes to store.

The storage problem takes two forms. The first, the storage of an environment while it is under development, is best dealt with via conventional memory technology, especially removable cartridge drives. The second, and more important problem, the delivery of a completed environment, is currently best carried out via CD-ROM. The ROM in CD-ROM stands for Read-Only Memory, since the CD can only be "read" by the user of such a system and cannot be written to, unlike standard disk drives found on most computers (while read-write optical systems are now available, they fall beyond the scope of the current paper). Due to the "read-only' nature of CD-ROM, as well as production cost, it is most appropriate for the storage. of information which is not subject to frequent change. Currently more than 540 megabytes of data (about 1,500 PC 360K diskettes or about 200,000 printed pages of text) can be stored on one 5-inch CD-ROM. The production of a CD-ROM is no longer difficult nor too expensive, and the decreasing cost of microcomputer technology in general, and CD-ROM technology in particular, should continue to make more accessible and enhance the presentation of large educational environments (Marini & Powell, 1990).

THE BROCK UNIVERSITY HYPERMEDIA LABORATORY CD-ROM PROJECT: A CASE STUDY

Inevitably, a small number of technically inclined individuals will embrace new technology with great vigour, regardless of how difficult it is to use. However, for the majority of language instructors, the issue invariably becomes one of considering whether the time and effort invested are really worth it. The work reported here was meant primarily as a full-scale field test of the ease of use and cost-effectiveness of a desktop CALL system of the type advocated here.

The Brock University Hypermedia Laboratory was established through a grant from the Apple Canada Educational Foundation. The core group involved in the CD-ROM project, which was called *Around the House,* was multidisciplinary in nature, involving faculty and students from Psychology (J. Mitterer), Applied Human Development and Child Studies (Z. Marini), Germanic and Slavic Studies (D. and B. Joe), and Computer Science and Information Processing (A. Powell). Additional assistance was given by C.

Federici (Italian), A. Amprimoz (French), C. Garcia-Gil (Spanish), A. Leverenz (Germanic and Slavic Studies), J. Damato, T. Banwell, K. Baboudjian and G. Schankula.

The particular desktop system used to design Around the House was assembled from Macintosh equipment, including a Macintosh II computer with 5 megabytes of RAM and an 80 megabyte internal hard disk (a second system, a Macintosh IIcx networked to the first, was also used but was not essential to the project). An Apple scanner was used to digitize graphics, MacRecorder was used to digitize spoken words, a SyQuest removable cartridge drive was used for intermediate storage, and an Apple CD-ROM was used to display the final result. The software used to design Around the House included SuperCard, a hypermedia program, the scanner software supplied with the Apple scanner, and digitizing software supplied with MacRecorder. The direct manipulation capabilities of the Macintosh desktop made it easy to integrate these programs into a powerful hypermedia development environment, It is worth pointing out that it is possible to use equipment which can perform a similar function in other computer environments, such as MS-DOS.

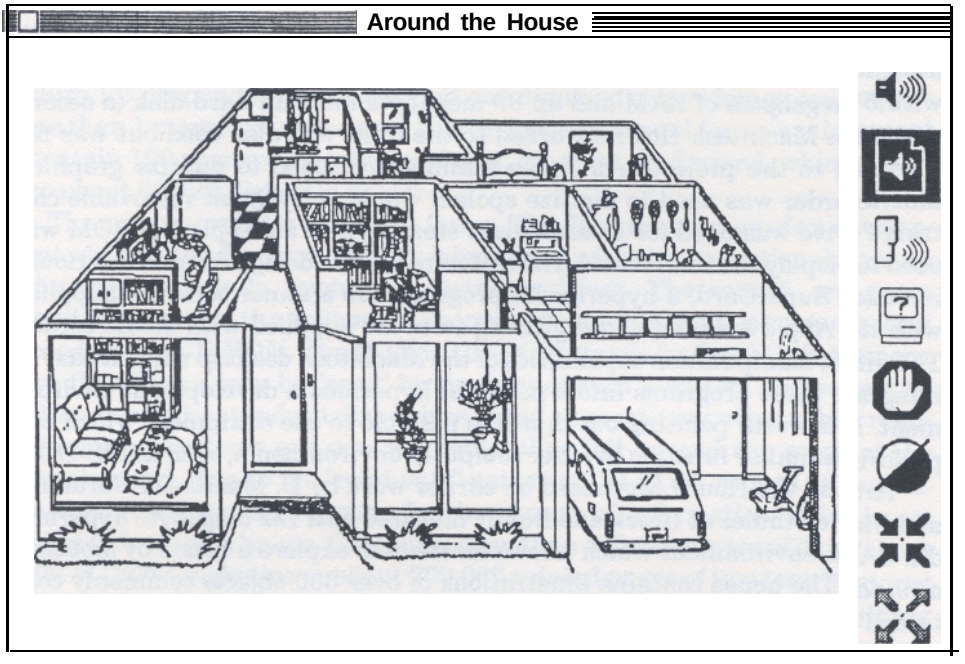
Around the House was based on earlier work by D. MacRae of Germanic and Slavic Studies at Brock and finally matured as a 122 megabyte hypermedia CALL environment which allows learners to explore a house by *mousing around*. The house contains illustrations of over 350 objects commonly contained in a *typical* house, and allows learners to discover the written and spoken word for the singular and the plural of each of those terms in five different languages: English, French, German, Italian, and Spanish. All of the graphics in Around the House were drawn freehand and were scanned using the Apple scanner. Written and spoken vocabulary was designed by team members, and spoken vocabulary was recorded with MacRecorder.

The design of Around the House was concerned primarily with presenting vocabulary information in an interesting manner that invited ongoing use. This led to a concern with a major issue in hypermedia development regarding the best way to let the language learner *navigate* through the material in a fairly natural fashion. To that end, navigational tools were designed to minimize disorientation. Another major concern was what happened when the learner encountered any particular vocabulary term. What follows is an account of how these issues were dealt with.

Problems of navigation and disorientation were addressed by relying on familiar graphical images and on navigation icons. This approach was favoured because it allows for language independence; learners need not be fluent in English to use the application. After theopeningscreens of Around the House, which allow access to instructions, the learner is presented with an overview screen which displays a cutaway illustration of a typical house, with a number of rooms visible.

Figure 1 (see page 178) forms the starting point, or anchor, for the exploration of the house and its contents. Each illustration of a room or an object includes a column of icons at the right side of the screen. These icons are used

FIGURE 1
Navigational Anchor Point Illustrating a Cutaway View of the House.



to control navigation and access vocabulary items. Such a layout provides easy access to the controls while focusing the learner's attention primarily on visual content by using most of the screen area for the illustration. The basic screen layout is used consistently, with the same column of icons appearing throughout. This consistency makes learning to use Around the House easier than it would have been had a more complex screen layout been used and provides an aesthetic integrity to the overall system.

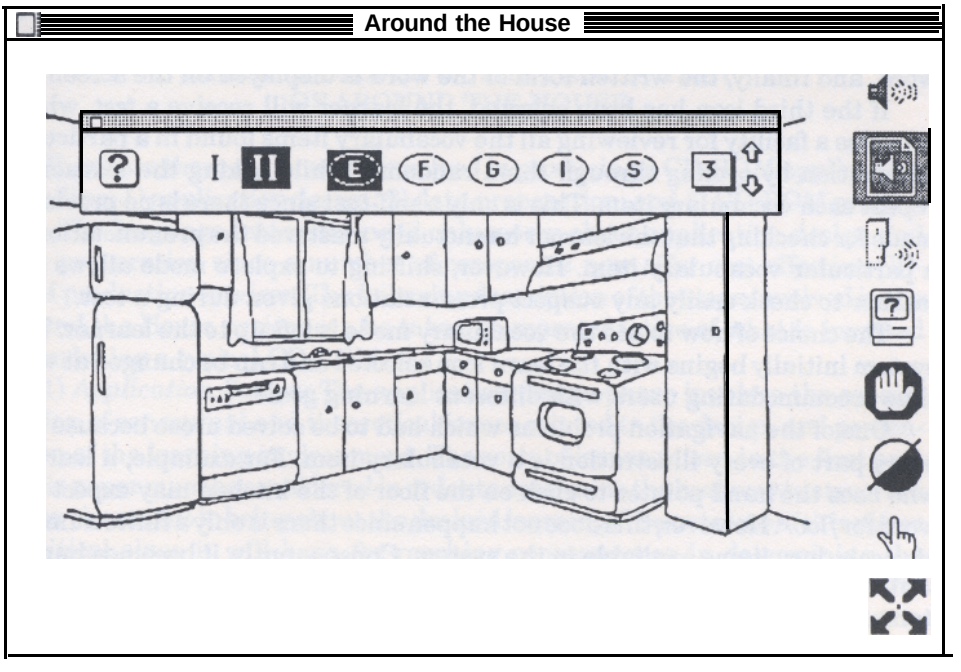
There are two fundamental modes of operation which can be selected by the learner. These two modes are toggled by clicking on the icon which is second from the bottom at the right of each illustration. The first, *navigation mode,* is accessed by clicking on the second icon when it is a hand, as seen in Figure 2; the second, *vocabulary mode,* is accessed by clicking on the second icon when it is a set of inward-pointing arrows, as seen in Figure 1.

When in the navigation mode, the learner can zoom deeper into the rooms and objects in the house. indicate that the learner is operating in this mode the cursor changes to a set of inward pointing arrows. For example, when presented with the top level cutaway illustration of the house, as in Figure 1, the learner could choose to zoom in on the kitchen simply by selecting this cursor, and then pointing and clicking on the kitchen in the house illustration, The cutaway of the house is then replaced with an illustration of the kitchen showing all the items in the kitchen, as in Figure 2 (page 1'79). Similarly, it

would be possible to zoom in on the refrigerator, and from there into the freezer compartment, and so on. In order to zoom back out to a higher level, the learner need only click on the zoom-out icon which contains a set of outward pointing arrows and is located at the bottom right of each illustration. From the freezer, for instance, clicking on this icon would return the learner to the illustration of the refrigerator. From there, clicking again would lead the learner back to the kitchen and then to the cutaway of the house.

Navigation through the house is completely under the control of the learner. The underlying conceptual structure is that of a hierarchy; at each

FIGURE 2
Control Panel for Selecting Help Menu, Plurals, Languages, and Feedback Speed.



level the learner is presented with a number of paths from which to choose. Each choice in turn leads to another set of choices, until the learner eventually reaches a terminal point where no more choices are available. What makes this conceptual structure particularly suitable is that it is difficult for the learner to become lost navigating within the house, since it is always possible to return to the anchor house illustration simply by clicking enough times on the zoom-out icon.

The actual content of Around the House can be found at all levels of the hierarchy and is accessed through a second mode of operation, the vocabulary mode. This mode is selected by clicking on the zoom-in icon, when it is second from the bottom at the right of each illustration, as it is in Figure 1. This

changes the cursor into a hand, which can then be used to point to particular items within an illustration. While in the vocabulary mode, what actually happens when an item is selected depends on which of the top three icons in the right-hand column of icons has been selected.

If the top icon has been selected, the learner can *explore*. Clicking on an item calls up a detailed illustration of it followed immediately by the spoken term for that item. For example, upon clicking on the refrigerator, which is embedded in the illustration of the kitchen, the application will show a more detailed illustration of a refrigerator and pronounce the word for *refrigerator* in whichever of the five languages is desired.

If the second icon has been selected, the learner can *learn*. Clicking on an item, such as the refrigerator in the kitchen, will initiate a sequence made up of three components: first the word for the item is presented in the context of asentence (e.g., "This is a refrigerator."), then the learner is asked to repeat the word, and finally, the written form of the word is displayed on the screen.

If the third icon has been selected, the learner will receive a *test*, which provides a facility for reviewing all the vocabulary items found in a particular illustration by cycling through them randomly while asking the learner to repeat each vocabulary item. This is only a self-test since there is no provision made for checking that the learner has actually mastered the pronunciation of a particular vocabulary item. However, shifting to explore mode allows the learner to check easily any suspect pronunciations given during a test.

The choice of how to use the vocabulary mode is left up to the learner, The system initially begins with the learn icon selected and can be changed at will, thus accommodating users with different learning goals.

One of the navigation problems which had to be solved arose because not every part of every illustration is a vocabulary item. For example, a learner who uses the hand pointer to click on the floor of the kitchen may expect the word for *floor*. However, this does not happen since there is only a finite number of vocabulary items available in the system. Consequently, it becomes important to signal which parts of each illustration represent selectable vocabulary items. This problem was addressed by providing a method for highlighting, or darkening, the available vocabulary items (typically from two to ten) in each of the illustrations. The highlight feature is activated by clicking on the sixth icon at the right side of every screen (again, refer to Figure 1).

The highlighting feature is also extremely useful in the navigation mode. Again, not every item in an illustration is decomposable into lower-level items and the learner cannot zoom-in on all the items. For instance, the refrigerator is divided into a freezer and cooler; thus it is possible to zoom in on the refrigerator. However, the ice-cube in the ice-cube tray cannot be further divided and is thus a terminal point. While in navigational mode, only those items which can be selected are highlighted.

A final important feature is the option. Clicking on the fourth icon on the right of each illustration calls up a small window (palette) which appears above the main illustration (see Figure 2). The control panel contains

a number of options. The desired language (English, French, German, Italian, and Spanish) can be selected by clicking on the appropriate icon. In addition, it is possible to choose to include plurals, to set the time allowed for repeating words, and to access the help system, which explains Around the House. The main benefit of putting these options in a palette is to allow the learner to hide them when they are not needed, thus reducing clutter on the screen. The functionality of the control panel is always available simply by clicking on the control panel icon. As well, the control panel can be left open and even "dragged" to another location on the screen which, for instance, allows the learner to click on the illustration of a chair with the language set to Italian, then switch to French with a single click in the palette window and click on the chair again.

STEPS INVOLVED IN THE PRODUCTION OF AROUND THE HOUSE

There are three major steps involved in producing a CD-ROM application, including: 1) application design; 2) data preparation; and 3) CD-ROM production. The language instructor need only worry about application design and data preparation since a number of companies now offer cost-effective ROM production services. The following description of the steps involved in the Around the House project can be taken as representative of what is involved in producing a typical CD-ROM.

1) *Application Design:* The application design phase involves the consideration of conceptual and theoretical issues related to the design and presentation of the learning environment. The sorts of issues raised in the first part of this paper must be considered in order to determine the best way to structure theenvironment tobringabout thedesired learning. Theoutcomeofthis phase is critical since it will have far-reaching consequences in determining the quality of the result. Most of the first part of the Around the House project involved planning the type of educational experience learners would encounter. Some of the issues considered at that time (e.g., navigation) are reported in the description of the project.

2) Data Preparation: The data preparation process involves the accumulation of materials and their conversion into electronic form, where required. For Around the House, this included creating and entering vocabulary lists into the computer, creating and scanning the artwork representing vocabulary items, and digitally recording the audio for the various languages. Furthermore, data preparation involves organizing the resulting body of electronic information into a particular structure, developing the software interface to allow access to these images and sounds, and possibly developing any software necessary to access the data when it is stored on the CD-ROM. The Around the House project relied on SuperCard, a HyperCard-like commercially available hypermedia program, to "glue" all of the electronic pieces together into a

coherent structure. As the project evolved, a large storage capacity was required. A number of standard hard disk drives, including a removable cartridge drive was used for storing the data. In total, approximately 280 megabytes of storage space were required (140 for the working version and 140 for a back-up).

3) CD-ROM Production: The Around the House application was stored on four removable 44 megabyte cartridge disks, which were then delivered to the manufacturer, who was responsible for completing the complex manufacturing process (see Marini & Powell, 1990, for further details). All that remained was to unpack the ten CD-ROM's which the manufacturer delivered the following week.

CONCLUDING COMMENTS

The main result of the Around the House project was that a desktop CALL system was assembled, allowing a dedicated multidisciplinary group without a high degree of technical sophistication to produce useful language learning materials while keeping development time and costs at a reasonable level. It is important not to take the development effort for this project as an absolute indicator of the effort required for comparable projects for two reasons. First, ongoing developments in the technologies underlying such desktop CALL systems will produce ongoing and dramatic improvements in the time and cost to develop future projects. Any estimates based on the Around the House project will be out-of-date very soon. Second, the effort required depends on experience. For example, experience gained in the Around the House project has resulted in a considerable reduction in the development effort required for subsequent projects (e.g., Marini & Federici, 1991). That experience has also produced several *lessons* which may be of interest to others considering the development of comparable CALL environments. These lessons include:

1) *Complete Designing the Application (as much as possible) Before Beginning to Prepare the Data:* Inexperience with the process of producing large bodies of material often results in a tendency to "plunge in" and to start preparing data before a sufficiently complete design emerges. This happened a number of times in the Around the House project and some of the time the design changes were judged to be vital and yet rendered useless some of the data preparation work under taken previously
2) *Make a Prototype:* Creating a single part of a single room in Around the House turned out to be very useful (it was the refrigerator in the kitchen). Many issues were ironed out in attempting to finish this fragment before full-scale work began. For example, it was immediately discovered that a rigid naming convention for all digitized sound files was requiredorelsecallingup thosesoundfilesat timewould

become haphazard. Since about 3500 of these files were involved (350 vocabulary items in 5 languages, in the singular and plural), it turned out to be most effective to write a single high-level procedure which searched for and played the appropriate sound file once a vocabulary item had been clicked.

3) *Do Not Trust Your Prototype to Scale up Linearly:* Moving from creating a prototype to creating the full environment can be a source of great difficulty. Once the prototype of Around the House was completed, it was assumed that the full environment would behave similarlyand so full-scale data preparation was begun; unfortunately, this assumption was not justified. For example, one important issue concerned the speed of the retrieval of sounds. Clearly, once a vocabulary item has been selected, Around the House should quickly retrieve and play the relevant sound files. Estimates of sound file retrieval times for the full environment were based on a linear extrapolation from the prototype. As it turned out, sound file retrieval times did not scale linearly, resulting in unacceptably slow times under some circumstances. Had this problem been clearly understood, the relevant section of Around the House could have redesigned to allow faster retrieval. The best solution for this sort of problem would have been to use the prototype to create a full-scale dummy model to test before actual production began. One way this could have been easily done for Around the House was by combining copies of the prototype (the refrigerator) until the size of the total dummy model approximated the size of the actual project. Testing this dummy *scale-up* would have quickly revealed the speed problem.

4) *Recognize the Paramount Importance of Navigation Issues: The* way in which the learner "moves about" in a CALL environment will determine the usefulness of that environment. If navigation is difficult, the environment will not be used, irrespective of the quality of the instructional content. Although considerable work went into designing the interface for Around the House, the result was not optimal. As outlined previously, different "modes" were used: the navigation mode was used for moving up or down the hierarchy of items in the house and the vocabulary mode was used for exploring vocabulary, Even though the appropriate mode could be selected simply by clicking on one of the bottom two icons on any illustration, this was perhaps the most difficult aspect of learning to use Around the House. Learners sometimes became confused about which mode they were in. Thus, a learner might try to navigate up or down a level while in vocabulary mode or to have a vocabulary item played while in navigation mode. In general, modeless systems are preferable because they allow the learner to access the capability of the entire system from every possible system state. Unfortunately, no simple design for a modeless interface to Around the House emerged before the project was completed.

5) *Devote Effort to the Design of Icons:* Since much of the functionality of CALL environments designed with hypermedia direct-manipulation systems is accessed by clicking on icons, it is important to design non-linguistic icons whose functions are intuitively clear and easy to remember. This was especially true for Around the House; most of the icons were useful since they were language independent and did not require the learner to be fluent in English to operate the system. If it is important to use icons which are difficult to remember, a possible enhancement would be to provide a single page quick reference help summary which should be accessed from a standard help icon available on all screens, rather than through a control panel palette. In cases where the application involves more than one language, the help screens should be translated into the other languages (this was not done for Around the House).
6) *Provide Alternative Ways of Accessing the Material:* As much as possible, alternate structures for accessing the information in the environment should be provided. Around the House currently allows only one access method: a traversal of the hierarchy is necessary in order to find a particular vocabulary item. A very useful alternate access method would be to allow dictionary-like lookups by providing a selectable list of words in each language.
7) *Help the Learner Keep Track of Exploration:* The original design of Around the House does not allow the learner to keep track of which vocabulary items have been covered. Although it is possible for a learner to systematically traverse all the items at a particular level and then proceed to the next level, the more usual approach is to explore only particular items of immediate interest. Although this is a strength, in that it provides for the optimum in learner control, it would be useful to indicate to a learner which items had been covered, without any sort of requirement that all items he covered in any particular order.

In closing, it is worth repeating that one of the major goals of this paper was to describe a way of applying technology to the service of language teaching by attempting to approximate real-life in the classroom. Although this has always been a goal of the language instructor, in the past technology made this goal difficult, if not impossible, to achieve. This paper provides some suggestions on ways of using the available technology to prepare better language instruction, where the needs of the language learner and the language instructor are met. The off-the-shelf desktop CALL system described here should be considered a minimal configuration for the design of language learning environments.

The strengths of the system described make it generally superior to many other approaches to CALL. In particular it is superior to many dedicated programs and to other authoring systems as well. The desktop system proposed in this paper offers a broad range of new alternatives to the design of

language learning environments by virtue of the fact that it is made up from the most effective tools currently available for recreating our relationship to the world around us. That they are relatively simple to use and inexpensive to acquire are added bonuses which cannot be overlooked. Through such virtues, these systems present language instructors with an opportunity to write their own finely-tuned applications. Such a system permits the design of dynamically interactive environments in which the needs of individual learners can be met: a fundamental prerequisite for good language learning.

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AUTHORS

Zopito A. Marini is an Associate Professor of Applied Human Development and Child Studies at Brock University, St. Catherines, Ontario.

John Mitterer is an Associate Professor of Psychology and Computer Science and Information Processing at Brock University.
Alan R. Powell is a Research Assistant at Brock University.

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